ROADS and STREETS

Vol. 81, No. 3 March, 1938

A GILLETTE PUBLICATION
ESTABLISHED 1906

SOIL STABILIZATION—

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A SHORT COURSE

Based on Exhibit of U. S. Bureau of Public Roads Displayed at the Recent Road Show

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Part II

BEFORE we can make much headway in an understanding of the theory and practice of soil stabilization we must visualize the meaning of the terminology. Certain words and phrases are used in discussing particular phases and operations involved in the behavior of soils under established conditions. Mere definitions of those words and phrases are incomplete in themselves, to establish an understanding or mental conception of the physical or chemical phenomena of the soils. Standard test procedure must be fully comprehended. They are the *elements* of the problem.

Furthermore, before we can make much headway we must realize that soil is stabilized for performing different services. Hence, it follows, that different values will have to be used for the factors involved.

To illustrate, if a soil is to be stabilized to be used as a surface of a road, a different plasticity index (P.I.) will have to be adopted than if that soil is to be used as a base for a road surface and still another value will be used if that soil is to be used as a sub-base or embankment.

Another illustration: Suppose a soil is to be stabilized for use as a road surface and it has been determined that a certain percentage of clay must be incorporated. Suppose there is no clay available at low cost. Then the question of admixtures arises. Either asphaltic material, tar, portland cement, raylig, blackstrap or other material may be used. The problem is one of economics of the local conditions.

Construction procedure typical to the various admixtures produces what is classified as a stabilized soil. So it is readily seen that the meaning of the words, soil stabilization, is broad and for that reason soils must be classified, analyzed and subjected to standardized tests.

TEST PROCEDURES FUNDAMENTAL TO ELEMENTAL UNDERSTANDING

During the growth of the science of soil stabilization it was soon discovered that soils had certain properties in connom:

1. All were composed of small particles that could be classified in sizes.
2. All absorbed water to more or less extent.
3. In their natural situ most all soils contained a certain amount of moisture.
4. Clays swelled more than granular materials when water was added.
5. Colloids were found to be present.
6. Vegetable and organic matter was discovered in most all soils.
7. Some soils supported loads better than others.
8. All eroded or abraded, in varying degrees.
9. Moisture could not be entirely eliminated except by heat.
10. Admixtures changed the properties of the soil mass.
11. Many other phenomena were discovered.

In order to analyze the soil properties intelligently

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tests were devised and standardized. It is not claimed that the tests are correlated to service conditions to which the soils will be subjected; that may or may not occur later by revision or substitution. They are mostly for identification purposes. Therefore, results of the tests have to be interpreted in the light of field service experiments and arbitrary standard limits adopted, employed, accepted, specified or used, as the case may be. These tests, then, give us a starting point from which we can systematize our investigations and also from which we can determine indicatory trends of behavior. With the results of a large number of tests at hand, properly systematized, a behavior analysis can be made and conclusions, in the form of hypotheses, drawn. These hypotheses establish the basis of the theory of stabilization. To date, enough laboratory experimental work has been done to establish certain theories. These are now undergoing verification by correlation with field

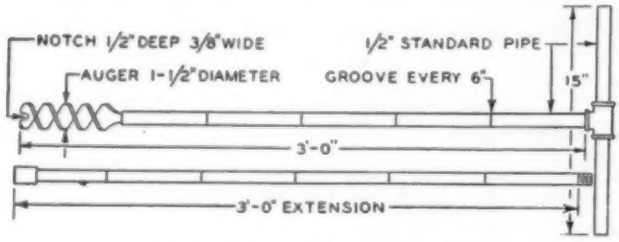


Fig. 1—Soil Auger and Extension

service. At this writing, such is the status of soil stabilization. At the same time it must be stated that stabilization is not an impractical theory; quite the contrary, it is highly practical and results obtained are economically beneficial.

In presenting the test procedures we shall start with the road soil. Obviously, the first thing we must do, is to get a sample of the soil at certain intervals along the route of the road or street under investigation. A standard method of surveying and sampling soils for use in place as subgrades for highways has been adopted by highway engineers. It is known as Method T-86, A.A.S.H.O. Standards.

Surveying and Sampling Soils for Use in Place

The purpose of the subgrade survey is to furnish the engineer with significant information on the following subjects:

a. The final location of the road, both vertically and horizontally.
b. The selection of suitable fill material.
c. The design of the roadway section.
d. The design and location of ditches, culverts, and drains.
e. The need for subgrade treatment and the type required.
f. The selection of the type of road surface and its design.

The subgrade survey is divided into three parts:

a. The determination of the soil profile.
b. The selection of samples for the determination of the physical properties of the soils included in the profile.
c. The mapping of the profile in order to supply information important to road design.

Determination of the Soil Profile—The soil profile is determined by examining the soil in its natural field condition. This work is best accomplished by examining excavations, road cuts, etc., but the method of using a soil auger is the most common. There is no definite rule to follow in making these examinations, except that the soil should be examined at intervals close enough to determine the soil type and by borings deep enough to penetrate the more or less nonuniform layers of soil or soil material.

The examination of the soil section should proceed in a systematic way, paying particular attention to the properties described below.

Texture.—The successive layers or horizons differing in texture or in fineness or coarseness of the material, should be carefully examined. The examination should extend to a depth of at least 5 or 6 feet below the proposed grade line. The texture of each layer and its thickness should be described.

Color.—The successive layers which can be differentiated according to differences in color should be noted. Each layer should be described and its thickness given.

Structure.—The several layers that differ according to structure should be examined carefully, structure being defined as the kind and size of soil particle aggregation. Special note should be made of horizons with (a) fine granular structure (granules about the size of bird shot or smaller); (b) coarse granular structure (granules ranging up to ½ inch or more in diameter and usually more angular or irregular in shape than the granules making up the fine granular structure); (c) layered or platey structure, in which the material splits into thin plates (not to be confused with stratification); (d) buckshot structure, in which the soil on drying breaks up into angular fragments (found to characterize heavy clays, usually having a considerable percentage of lime); and (e) single-grain structure in which the material is like flour or sand, with no aggregation of particles.

Consistency.—A determination should be made of the successive layers or horizons differing in consistency (stickiness, friability, plasticity). A description of each should be given and its thickness noted.

Compactness.—The relative compactness of the several layers should be determined, as measured by the degree of resistance to the penetration of a pointed instrument.

Cementation.—It should be determined whether or not resistance to penetration is due in any horizon to cementation. If so, the probable cementing material (light colored or reddish, very strongly cemented or weakly cemented) should be ascertained.

Chemical composition.—While the determination of the chemical composition of the various parts of the soil section or profile can not be performed in the field by the usual field methods, there are certain features that may be determined in at least a qualitative way. Field examination can detect the presence of horizons with concentrations of organic matter or of salts of the alkalies and alkaline earths.

The organic matter referred to here is that contained in the soil and not that lying on the soil. Of this there are two kinds to be looked for: (a) The organic matter in the surface soil is recognized by the dark color, and the approximate relative percentage present is indicated by the intensity of the dark color. The determination of the thickness of the dark-colored layer in the virgin soil is very important. (b) In some soils, usually confined to regions with a cool, moist climate, there is present, at a depth ranging from 6 inches or less to somewhat more than a foot, a layer of brown or coffee-brown organic matter forming a film 6 or 8 inches in thickness.

The salts of the alkalies and alkaline earths accumulate in the soil under favorable conditions. Since the work here contemplated is general and the soil characteristics dealt with are those of wide regional distribution, we may practically neglect all salts except the carbonate of lime. The more soluble salts constituting what is usually known as "alkali" are present in relatively small areas and may be neglected, or the soils in which they occur may be designated as mere alkali soils.

Horizons of lime carbonate accumulation may be identified readily by anyone and should be looked for where the rainfall is less than 17 to 18 inches per year in cool to cold climates and 30 inches per year in hot or very warm climates. The unweathered material beneath the soil in any region, arid, subhumid, or humid, may have a high percentage of lime carbonate, but such material should not be confused with the horizon of true lime carbonate accumulation.

Sesquioxides accumulate in the soil under favorable conditions. Since accumulations of aluminum hydroxide are not readily identified by the usual field methods, these may be left out

of consideration. We are concerned, therefore, with accumulations of iron oxides.

Iron oxides occur in two forms: The first form consists of accumulations of finely divided or colloidal iron oxide (hydroxide). The degree of concentration may be determined, within a rather wide range of error by the intensity of the red color. The existence of red horizons in the soil profile should be noted and should be illustrated with samples, even though they be small. The second type consists of accumulations of iron oxide concretions or large masses, usually porous or slaglike. This statement does not refer to ironstone slabs or ferruginous sandstone layers which may be found in many places in the parent geological formations. In hot countries the accumulations referred to here take the form of thick masses of porous slaglike iron oxide lying at depths ranging from somewhat less than 3 to more than 15 feet. They may consist of fragments scattered over the surface.

Selection of Samples—A 5-pound sample of soil from each layer is obtained with pick and shovel from the exposed back slopes or from test pits dug at locations indicated by the borings. Each sample should be placed in a canvas bag, tied securely, marked with proper identification and shipped to the laboratory. A sufficient number of samples must be taken to determine the range in test results for what appears to be the same layer.

A discussion of the mapping of the soil survey profile is desirable at this point, but the subject is too lengthy for this installment. The writer desires to deviate from the mechanics of testing only far enough to show how it fits into the general subject. Those interested in the subject of how soil surveys should be made may refer to page 216, Standard Specifications for Highway Materials of the American Association of State Highway Officials.

Soil Classification

In the preceding section it was shown how a survey is conducted to determine the distribution of soil types in a given area. In summarizing this procedure we might say that the engineer selects samples of all of the soils that differ in appearance and enough samples of similar materials to establish their identity.

The next problem is to analyze the soil samples to determine their individual properties and probable field behavior and also to determine which of the samples belong to the same field strata. In order to fully appreciate the method of soil classification the following outline of the development of this new science is included.

Development of Soil Science—A number of years ago each engineer faced the fact that although every structure that he designed was controlled by rigid formulas, the foundations on which they were usually built were unknown variables. This was recognized even more often by the highway engineer who noticed that some soils would support light traffic under all weather conditions, some were stable in dry weather but impassable in wet weather, some would carry traffic in wet weather but were rough and dusty in dry weather, some would serve as stable subgrades, others would swell and disrupt pavements laid on them; some could be compacted to a permanent high density, others were so highly elastic that artificial compaction was ineffective; some were subject to frost heave, etc. Gradually there came the realization that soil is not just plain "dirt" but under proper control is a very important structural material.

Under the impetus given soil studies by the demand for low-cost roads the U. S. Bureau of Public Roads systematically investigated all of the different soil types that exhibited characteristic field behavior. First they secured sufficient samples from the field to reproduce complete profiles. Next these samples were submitted to the laboratory and subjected to a series of *arbitrary* tests. Lastly, the test constants of all soils having similar structural properties in the field were listed as limiting values for different behavior groups. On the basis of this work it was found that there are eight distinct types of soils varying in structural properties as follows:

A-1; Excellent binder for soil roads, containing proper balance of coarse and fine material, high internal friction, and cohesion. Absence of detrimental shrinkage, expansion, capillarity or elasticity.

A-2; Contains either an excess of clay or an excess of sand. May be stable in dry weather and soft in wet weather or rough and dusty in dry weather and fairly stable in wet weather.

A-3; Almost pure sand. Flows under wheel loads but furnishes excellent supporting medium.

A-4; Predominance of silt. Absence of cohesion. Absorbs water so quickly as to disrupt structures. Subject to serious frost heaving. May form stable road when dry but will soften in wet weather.

A-5; Predominance of silt as in A-4 but with added elastic properties, even in the dry state. Will not retain compacted density.

A-6; Predominance of sticky, colloidal clay. Practically nonelastic and can be compacted to high, permanent densities. Bentonite one example. Absorbs water slowly and has high shrinkage. Often interferes with macadam bond.

A-7; Predominance of clay but often elastic. May have tremendous volume change and cause concrete pavements to crack and fault.

A-8; Contains large amounts of peat or muck. Spongy. Will settle under load. High capillarity and elasticity.

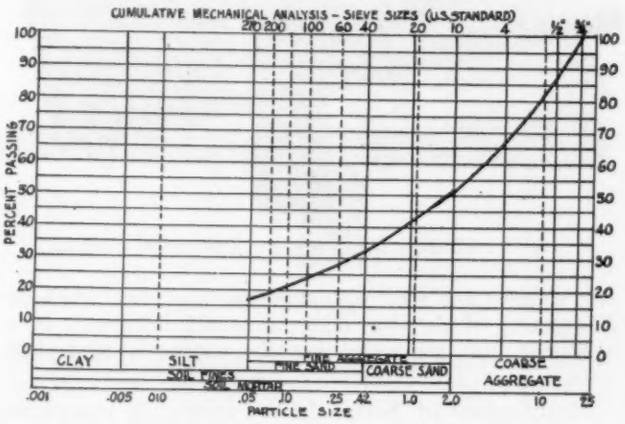


Fig. 2—Cumulative Gradation Curve of Table I Grading

When samples are submitted to laboratory examination they are tested by the same arbitrary procedure adopted by the Bureau of Public Roads in their original investigations. Then the test constants are compared with the limits established for the different behavior groups. *The soil is then classified as belonging to the behavior group whose constant it most closely approaches. Thus it may be seen that the process of soil classification is not one of evaluating each test value as a numerical expression of one or more definite properties but the identification of one soil as being similar to samples which have been selected as standards and whose properties are known.*

Let us now go through more or less of a "play-by-play description" of the testing and classification of one of the soil samples we might have taken on our original survey.

Mechanical Analysis and the Determination of Subgrade Soil Constants

The samples, about 5 lb. each, would be sent to the laboratory, probably in a small canvas bag. Since they

would most likely be moist they would be spread out in large shallow pans and allowed to dry *without the direct application of heat.* After they became so dry that dust would form when the lumps were rubbed with the fingers, they would be pulverized in a large porcelain mortar by a rubber covered pestle.

From these large samples there would be quartered out approximately one of the following amounts depending upon the amount of gravelly material.

If largely silt and clay	65 grams
If of sandy texture	115 grams
If containing gravel, at least	500 grams

The rest of the sample would be passed through the

Fig. 3.—Showing Equipment for Mechanical Analysis.

No. 40 sieve and the coarse material discarded. At least 300 grams of the fine material would be placed in a container and set aside for the moisture equivalent tests.

Modification of Tests—In the following procedure it will be noted that two tests have been omitted; the hydrometer method of analysis and the centrifuge moisture equivalent. There are two reasons for this: first, there has been an attempt to limit the required equipment to that which could easily be included in an inexpensive field laboratory, and, second, the procedures for

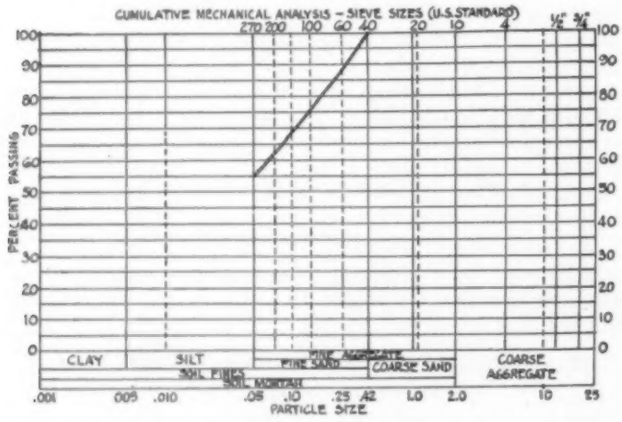


Fig. 4—Cumulative Gradation Curve of Soil Mortar Portion of Table I Grading.

these tests are necessarily long and somewhat tedious. If a laboratory is faced with a limited budget it is felt that the tests which are included should prove most useful. Also, such a laboratory could probably be made into a portable unit.

Sieve Analysis—The portion of the sample set aside for the mechanical analysis is allowed to dry in an oven at approximately 110 deg. Centigrade, overnight. It is then weighed and passed through a nest of sieves of the sizes shown in Table I. The material remaining on each sieve after thorough shaking and that passing the No. 200 is weighed on a suitable balance.

Table I
Mechanical Grading

Sieve Size	Wt. in Grams Retained	Per Cent Retained	Cumulative Per Cent Passing
1 inch	0	0	100
¾ inch	10	2	98
⅜ inch	80	16	82
No. 4	85	17	65
No. 10	75	15	50
No. 40	95	19	31
No. 270*	70	14	17
	—	—	—
Passing 270	85	17	—

Total Grams—500
*No. 200 mesh sieve often substituted.

A study of the table will show for the last column that the cumulative per cents reported as passing, for example, the No. 4 sieve is 65; i.e., 65 per cent of the 500 gram sample went through No. 4 sieve. Incidentally, this gradation will make a good stabilization mixture.

Sometimes it is necessary to wash the portion of the sample retained on the No. 200 sieve through that sieve. The amount passing is computed from the dry weight of the original sample and the combined dry weights of the materials remaining on the several sieves. The values in the last column of Table I are usually plotted, as shown by Fig. 2, as a grain size accumulation curve.

For the routine identification it is also necessary to compute the distribution of material passing the No. 40 sieve. This is done by No. 40 as representing 100 per cent and multiplying the other values by correction factors. That is, with the No. 40 value of 31 per cent, the value for No. 200 would be corrected by multiplying 17 by 100/31, which is 55 per cent. The reason for this is that in designing a mixture it has been discovered that the fraction passing the No. 200 sieve should be less than two-thirds (⅔) of the fraction passing the No. 40 sieve. A grain size accumulation curve for this fraction is shown in Fig. 4.

Hydrometer Test.—The American Association of State Highway Officials and the American Society for Testing Materials have set up elaborate, involved procedures for determining gradations of the minus No. 40 fraction by using hydrometers, graduates and mechanical stirring devices. We believe these are too elaborate for field checks and have therefore not included discussions about the method.

The test is used to determine silt and colloidal gradations. Pennsylvania has established a field outfit for rough checking during construction. Their procedure follows:

Before spreading and compaction is attempted, field hydrometer tests determining the quantity of the soil passing the No. 270 sieve is made. Similar hydrometer determinations must be made in the case of plant mixing. The test is made on each 1,000 feet of mixed material.

If the field hydrometer readings do not check with the laboratory results a sample of the mixture is sieved and tested with hydrometer in the field. From this analysis it can be determined whether the mix needs an increase or decrease in granular or colloidal material. After the adjustment is made a sample of the adjusted mix is sent to the laboratory for analysis. The definite field test procedure will appear in the next installment.

Moisture Equivalent Tests—With the exception of the mechanical analysis all of the routine identification tests disclose the moisture content at which some property or limiting value of some property of the soil is manifest. Thus, all of the test constants are expressed in terms of moisture content. Therefore, the following procedure is given for determining this value.

Apparatus Required.—Constant temperature drying oven or alternate field camp stove and portable oven; one thermometer 0-200 deg. C.; two dozen paired watch glasses and clamps; one triple beam balance, capacity 110 grams, sensitive to .01 grams; one spatula and a desiccator.

Procedure.—From 10 to 20 grams of the wet soil is removed from the mass with a spatula and placed in a watch glass. The cover glass and clamp are quickly fitted in place. The wet soil (in the glass) is weighed and then placed in the oven overnight. The dry sample is then removed from the oven and cooled in a desiccator. It is then weighed and the moisture content computed from the following formula:

$$\text{Percent water} = \frac{\text{Weight of wet soil - Weight of dry soil}}{\text{Weight of dry soil}} \times 100$$

The weights of the wet and dry soil are, of course, determined by subtracting the weight of the glasses from the total weight of soil and glasses. These values for a typical case are shown in the following table:

Wet soil and dish	45.41
Dry soil and dish	35.20
Weight dish	11.09
Dry Soil	24.11
Water	10.21
Percent Water	42.3

Liquid Limit—This is defined as the percent of moisture at which the soil changes from a plastic to a liquid condition. It is liquid when it begins to flow under certain arbitrary conditions as explained below:

Apparatus Required.—Liquid limit device with grooving tool (strongly recommended as against hand method); 25 ml. graduated burette with stand; spatula, distilled water.

Procedure—Machine Method: 30 grams of the soil are placed in the brass dish and thoroughly mixed with water (added for convenience through the burette) to a stiff but workable state. The surface is smoothed off in a half-moon in the front of the dish and a groove cut with the special tool. The cup is pinned in the machine and the crank is turned. The number of shocks required to just close the groove cut in the sample is recorded and the moisture content determined by oven-drying a small sample as discussed previously. The soil is again wetted and the entire procedure repeated until there are several values ranging about 25 shocks. The data are then listed as shown:

Moisture Content	Number of Shocks
32.6	16
33.9	22
35.4	32
36.3	40

A plat of the data for this hypothetical case is shown in Fig. 5. The moisture content corresponding to 25 shocks on the curve is the true liquid limit.

Procedure—Hand Method: The soil is mixed with water in a porcelain evaporating dish until the groove is just closed by 10 shocks against the wrist. The moisture content is determined only once, at the end point. This method is subject to considerable personal error, especially among different operators.

Fig. 6.—Equipment for Determining Liquid Limit and Plastic Limit.

Plastic Limit—This is defined as the percent moisture at which the soil changes from a solid to a plastic condition.

Apparatus Required: Glass plate for rolling.

Procedure—Usually some of the soil remaining from the liquid limit test is mixed with some dry soil until it is just slightly workable. It is then rolled with the palm of the hand over the glass plate into threads ⅛ inch in diameter until these threads just began to crumble. The moisture content is then determined.

Plasticity Index—The numerical difference between the liquid limit and the plastic limit is defined as the plasticity index.

Shrinkage Test—This is the volumetric shrinkage.

Apparatus Required—Glass cup with ground glass edge, glass plate with three prongs, milk dishes, steel straight-edge, 25 ml. glass graduate, mercury, porcelain mixing dish, spatula, distilled water.

Procedure.—The soil is mixed with water to slightly above the liquid limit. It is then placed in a milk dish in three layers and after each addition it is carefully tapped to remove the air bubbles. The soil is then scraped off level to the top of the dish with the straight edge and the sample weighed. It is first air-dried and then oven-dried to constant weight. After cooling in a desiccator the dry weight is obtained. The moisture

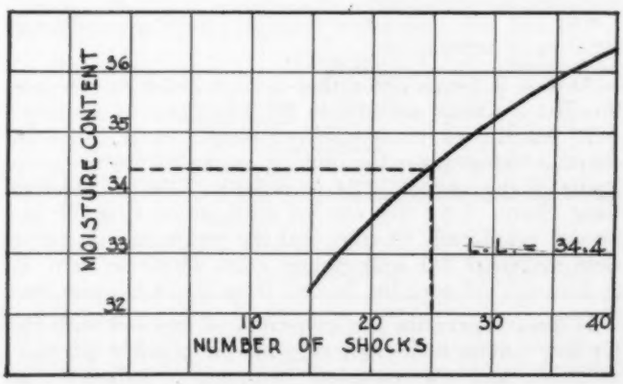


Fig. 5.—Showing Method of Determining Value of Liquid Limit.

content is computed as shown above. The volume of the pat is determined by filling the glass cup with mercury, immersing the specimen and measuring the overflow in the 25 cc. glass graduate.

The shrinkage limit and shrinkage ratio are computed as follows:

$$\text{Shrinkage limit} = \text{Moisture content } (\%) - \frac{\text{Volume of dish} - \text{Volume dry soil}}{\text{Weight dry soil}} \times 100$$

$$\text{Shrinkage ratio} = \frac{\text{Weight of dry soil}}{\text{Volume of dry soil}}$$

Field Moisture Equivalent—This is the minimum moisture content expressed as a percentage of the weight of the oven dried soil, at which a drop of water

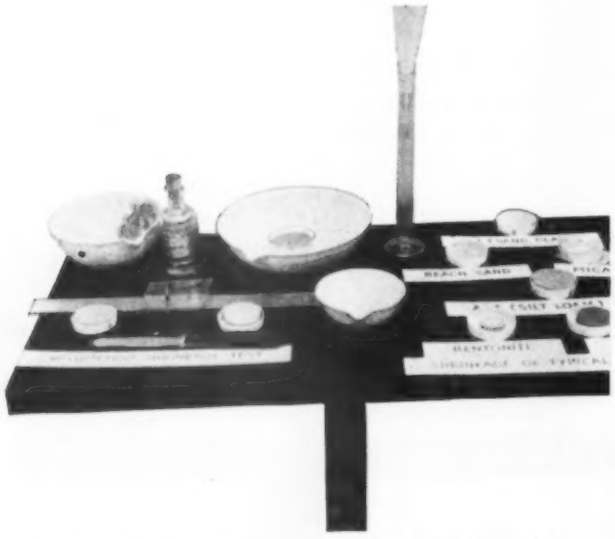


Fig. 7.—Equipment for Determining Volumetric Shrinkage.

placed on a smoothed surface of the soil will not immediately be absorbed, but will instead spread out over the surface and give it a shiny appearance.

Apparatus Required.—25 ml. graduated burette, and

Fig. 8.—Equipment for Determining Lineal Shrinkage and Field Moisture Equivalent.

stand, stop watch or clock, spatula, porcelain mixing dish, distilled water.

Procedure.—The soil is mixed with water until it will "ball up" slightly. A small area is smoothed off with the spatula and a drop of water allowed to fall on it. While the drop remains on the surface it appears shiny and when it is absorbed this luster is lost. The time required for the water to be absorbed is noted and the soil is mixed with different amounts of water until the drop is absorbed in just 30 seconds. The moisture content is then determined.

Fig. 9.—Colorometric Test Equipment for Determining the pH Value of Soil.

Soil Acidity or Alkalinity—A simple test to determine whether a soil is acidic or not, and how much, is made with colorometric test equipment to determine the pH value. While considerable could be written about base exchange and ionic action in soil from admixtures, suffice it to say that there is an indication that in the more acid soils a little admixture of lime material is beneficial. There is an indication that the chemical might be retained longer if such admixtures are used, than if they are not used.

Routine Classifications

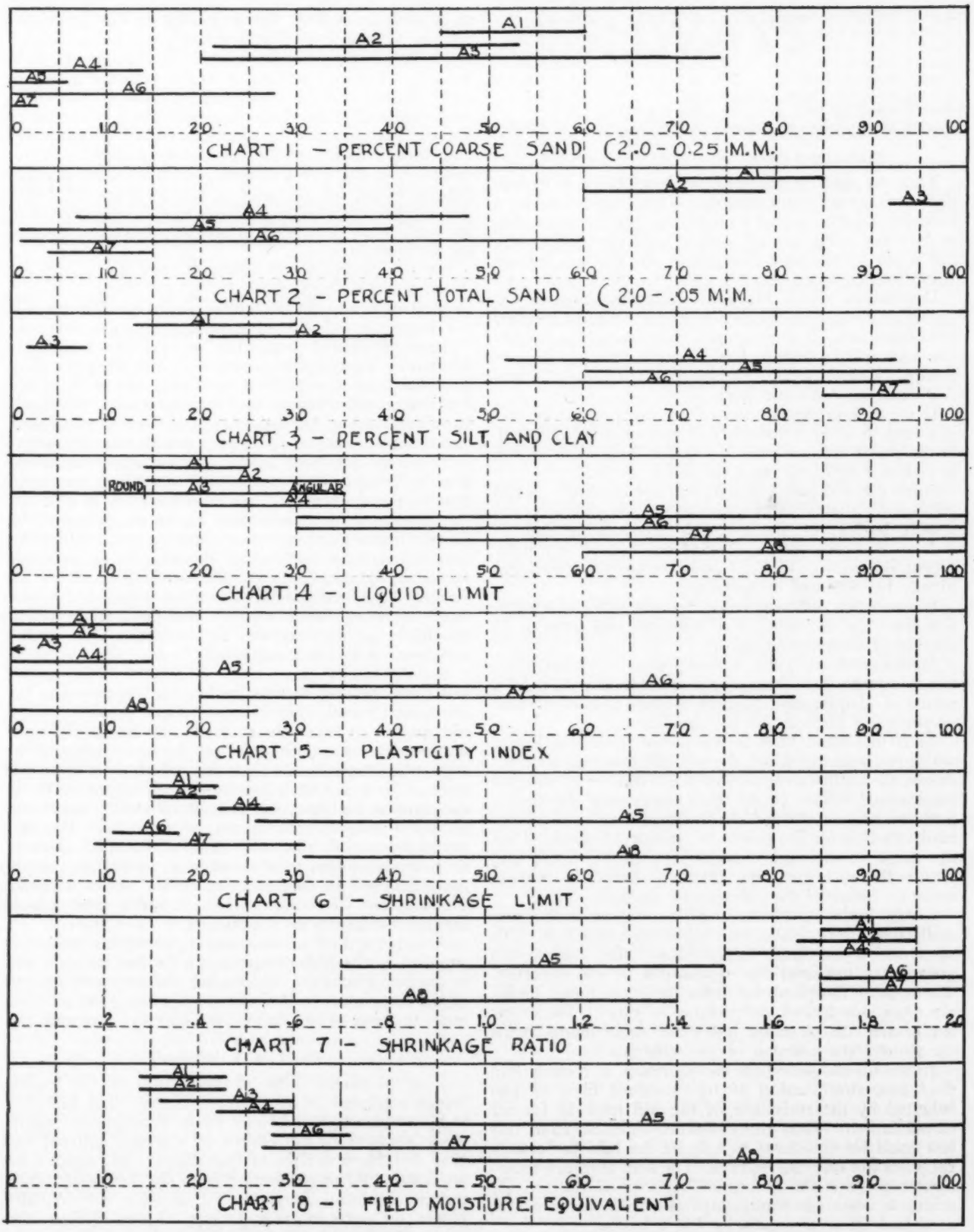
Let us suppose that two of the soils we tested had the following grading and moisture equivalent values.

	No. 1	No. 2
Coarse sand (Sieves No. 10-60)*	0	13
Total Sand (Sieves No. 10-270)*	1	34
Silt and Clay (Passing No. 270)*	92	66
Liquid Limit	51	27
Plasticity Index	31	0
Shrinkage Limit	13	27
Shrinkage Ratio	1.9	1.6
Field Moisture Equivalent	34	27

*Obtained from intermediate values on grain size accumulation curves or by extrapolation.

At first it seems like rather a large order to compare this list of values with those for a number of standard soils but this is rendered very simple by a series of charts which express the limiting values of the test constants of the various soils graphically. Let us refer to these charts, 1-8. By way of explanation Chart 1 expresses graphically the fact that the percentage of coarse sand in group A-1 soils ranges from 45-60 per cent, in A-2 from 2-53 per cent, in A-3 from 20-74 per cent, etc.

If we compare the test constants of any soil with the limiting values, each chart suggests the possible soil classification and the complete comparison indicates the final classification.


A1
A2
A3
A4
A5
A6
A7
A8
0 10 20 30 40 50 60 70 80 90 100
CHART 1 – PERCENT COARSE SAND (2.0 – 0.25 M.M.
CHART 2 – PERCENT TOTAL SAND (2.0 – .05 M.M.
CHART 3 – PERCENT SILT AND CLAY
ROUND
ANGULAR
CHART 4 – LIQUID LIMIT
CHART 5 – PLASTICITY INDEX
CHART 6 – SHRINKAGE LIMIT
0 2 4 6 8 10 12 14 16 18 20
CHART 7 – SHRINKAGE RATIO
CHART 8 – FIELD MOISTURE EQUIVALENT

Charts 1 to 8, above, indicate the limiting values of identification tests of arbitrarily standardized soils of known behavior characteristics. How the charts are used is completely explained in the text.

We can summarize these comparisons as follows:

	Soil Groups	
	Sample No. 1	Sample No. 2
Chart 1, percent coarse sand	A-4, 5, 6, 7	A-4, 6
Chart 2, percent total sand	A-5, 6	A-4, 5, 6
Chart 3, percent silt and clay	A-4, 5, 6, 7	A-4, 5, 6
Chart 4, liquid limit	A-5, 6, 7	A-2, 3, 4
Chart 5, plasticity index	A-5, 6, 7	A-2, 3, 4, 5, 8
Chart 6, shrinkage limit	A-6, 7	A-4, 5, 7
Chart 7, shrinkage ratio	A-1, 2, 4, 6, 7	A-4
Chart 8, field moisture equivalent..	A-5, 6, 7	A-3, 4, 5, 7
Predominant group	A-6	A-4

Thus we see that the first soil is of the A-6 variety since this group predominates. This happens to be a colloidal clay that proved troublesome. It created a slide in Missouri. The second sample is of the A-4 variety and is one of the New Hampshire silts that are subject to detrimental frost heave.

Discussion.—This method of classification is designed as a rapid procedure that does not require previous soil experience. It is recognized that some of the borderline soils will be indicated as belonging to two separate groups. Among such soils can be listed the A-1's and A-2's and the A-5's and A-8's.

If the A-1 group is indicated by every chart the soil is a true A-1, even though A-2 may also be indicated. If the charts indicate both A-1 and A-2 although neither is indicated by every chart the soil is an A-2.

Often the A-5 and A-8 soils will not be clearly distinguished by these charts. However, this difficulty can usually be met by the practical consideration that an A-5 soil is similar to pumice and an A-8 soil is usually a peat or muck. The difference between the two can usually be discerned by inspection.

If inspection will not enable the separation of borderline cases the individual test constants will have to be considered as discussed below.

Significance of Test Constant Values.—Although the test constants have been suggested for use only as a means of identification they do indicate certain inherent properties of the soil that are significant.

Thus the liquid limit is considered to be the lowest moisture content at which the soil will flow and is an index of the capillary capacity of the soil when thoroughly manipulated. The plastic limit represents the lowest moisture content at which the moisture films supply sufficient cohesion for the soil to be considered plastic. Thus the range in moisture content between the liquid and plastic limits, termed the plasticity index, is thought to be an index of the cohesion of the soil.

Liquid limits up to about 20, or slightly more, generally indicate materials with negligible capillarity. The more the liquid limit values exceed this amount the greater are indicated the capillarities of the materials. The greater the plasticity index for equal liquid limits, the more is indicated the presence of clays. Therefore, the greater the plasticity index for equal liquid limits, the greater the cohesion of the materials.

In the shrinkage test the soil decreases in volume until the "squeezing" action of the moisture films is just balanced by the resistance of the soil mass to further consolidation. Thus the constants obtained from this test could be considered to indicate the balance between cohesion and internal friction. The field moisture equivalent represents the absorption capacity of the soil for moisture when not manipulated and is an index of the combined effect of capillarity and cohesion.

It should be stressed that the above classification is of a general nature. However, by keeping in mind the significance of the test results and profiting by experience real progress should be made in this new science.

(*To be Continued*)

A. G. C. Resolves

Immediate withdrawal of government from competition with its citizens was demanded by the Associated General Contractors of America in a resolution adopted by its 19th annual convention, held in Washington, Feb. 8 to 10. The competition of WPA with the construction industry, and the continuing threat of expansion of such competition has been responsible in a great degree for the postponement or abandonment of contemplated and needed facilities, the association asserted. A resumption of the PWA program and a revision of WPA policies to require the relief agency to utilize the facilities of the construction industry in the management of its work were demanded in another resolution adopted by the convention.

Further governmental action in restoring private industrial activity was called for by the association in a resolution protesting the undistributed profits tax and the imposition of any other penalty taxes on business. "The undistributed profits tax has imposed a hardship in creating a penalty on productivity and created a positive retardent in expansion and development in manufacturing, construction and transportation, seriously curtailing the purchasing power of millions of consumers to buy the products of agriculture and all other industry."

The wage and hour legislation now under consideration by Congressional committees was given the attention of the convention. Its resolution stated that the construction industry now pays higher wages and works shorter hours than any other industry and any legislation would have little effect directly on construction. However, it stated, the association is opposed to the enactment of national legislation on wages and hours, since such legislation would "disrupt local economic conditions in large sections of the nation and further complicate economic conditions."

Social security taxes under present laws in several states will cause a serious hardship to construction, the convention stated. Merit rating plans, providing for a sliding scale of taxes, the amount to be determined upon the measure of continuity of employment furnished by a given employer, will be put into effect soon in several states. Such a system will be entirely impracticable in the construction field, the convention stated, since continuity of employment cannot be provided. Workers cannot be carried from one territory to another, the convention's resolution pointed out, and, in addition, conditions imposed on contracts for public works requiring the securing of workers from a given area impose further restrictions on contractors.

A large section of the total construction market is supplied by the highway program, the convention stated in another resolution, which gave the emphatic support of the association to the bills now pending before Congress to continue the federal aid highway program.

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Dr. J. A. L. Waddell

John Alexander Low Waddell, one of the leading bridge engineers of the United States, died March 4 in his apartment in the Hotel Earle, Washington Square, New York, from the effects of a stroke suffered last Nov. 15. He was born in Port Hope, Ont., eighty-four years ago. After graduating from the Rensselaer Polytechnic Institute, Troy, N. Y., in 1875, Dr. Waddell passed six years in railway work. From 1882 to 1886 he was Professor of Civil Engineering in the University of Tokyo, and then returned to this country and opened a consulting office for bridge engineering in Kansas City. In 1920 he moved his headquarters to this city. Since 1927 the firm has been Waddell & Hardesty.

ACTION PROGRAM TO ADVANCE SAFETY ON HIGHWAYS

By THOS. H. MacDONALD

Chief, U. S. Bureau of Public Roads, Washington, D. C.

THE advancement of safety on the streets and highways of the nation requires definite action on many fronts. The desirable objective for the year 1938 is a vigorous, concerted movement to bring into being on an effective scale the measures and methods which the present knowledge of the character and scope of the problems sustains as a sound program.

No Single Cause of Accidents

Perhaps the most important single principle developed during the year just closed of extensive study by the Bureau of Public Roads and the Highway Research Board of many phases of this subject is that there is no single cause of accidents. Each accident is the result of causes in combination. There are always present more than a single element and the number of these elements that can and do contribute to accidents is very large. The possible number of combinations of these elements by mathematical calculation produces a potentiality of accidents of a magnitude beyond conception. Probably the failure of the law-makers to recognize this characteristic of multiple contributing elements in each accident has acted as a powerful deterrent to more effective programs of accident control. Certainly it has given rise to serious delays in formulating and applying sound preventive measures.

For example, the hope that a single panacea exists that will stop accidents, although utterly absurd, results in all sorts of cure-all offerings, many of them from so-called experts or near experts. Since there is no single cause there can be no single panacea for accidents. On the other hand, the recognition by the courts of multiple accident-contributing elements has resulted adversely to the imposition of even reasonable penalties upon offenders of the traffic laws. Here the recognition of the contributing factors mitigates to the point of allowing, in many cases, the offender to escape without price the most serious infractions of the law. So widespread is this experience as to lead to the reasonable conclusion that reliance for any great assistance in accident prevention does not lie in the courts as they are now operated in the field of traffic regulation.

Sufficient recognition has not as yet been given to the fact that this big problem of street and highway safety throws upon the established routine and traditions of the courts a new social problem of tremendous dimensions with which they are not designed to cope. The processes of the courts are not singled out for criticism in themselves but to illustrate the failure of society as a whole to recognize the tremendous dimensions of the street and highway traffic safety problems and to provide adequate methods and organizations to deal with these problems effectively.

Reports on Accidents on Highways

A year ago Congress directed the Bureau of Public Roads to undertake a study of the problem involved and to submit a report. Acting in cooperation with the Highway Research Board the Bureau has produced a report or rather a series of reports dealing with the following subjects:

1. Non-Uniformity of State Motor Vehicle Traffic Laws.
2. Skilled Investigation at the Scene of the Accident Needed to Develop Causes.
3. Inadequacy of State Motor Vehicle Accident Reporting.
4. Official Inspection of Vehicles.
5. Case Histories of Fatal Highway Accidents.
6. The Accident-Prone Driver.

These reports have all been transmitted to Congress and are now in process of printing. They will be available for general distribution almost immediately. By acting through the Highway Research Board not only the previous studies which had been made by that Board were available, but it was possible to secure the assistance of the individuals who were already working in the several fields of investigation and who have devoted their best efforts to the studies and the resulting reports. Further, a number of the leading authorities, representatives of organizations primarily concerned in the traffic safety field, served as an advisory committee to make suggestions as to the scope of the studies and the production of the report.

An Action Program Proposed

It is not the purpose of this paper to review the findings of these reports, but on the basis of the material developed, to propose an action program for the immediate future and to fix in so far as possible the responsibility for the initiation of this program. Neither is it the purpose to prove by the use of statistical material the urgent necessity for enlarging, and quickening the tempo of, sound national programs directed toward the control of the tragic record of accidents and fatalities. A responsible attitude of good citizenship and intelligent selfishness places the road builders and road building industry of the nation behind every effort to advance the cause of highway safety. In this social problem already grown to such alarming dimensions that it ranks as one of our greatest national problems, while most of the implications and indications are discouraging there is one important encouragement. Under the coordinating influence of the Automotive Safety Foundation, twelve national organizations which are most intimately and directly concerned with traffic safety problems have united in accepting the recommending a comprehensive model program for each state to increase traffic efficiency and to reduce accidents. This program brings into a coordinate entity the elements of legislation, motor vehicle administration enforcement, engineering, education, training personnel and research.

It places responsibility for action upon the Governor, the state officials and the legislature supported by a non-official organization of civic and business groups. The combination of official and public groups is conceived

to constitute the State Safety organization. With this program the Bureau of Public Roads is in entire accord and holds it to be indicated by all the important studies and researches which have been made in this field.

While it may appear to the public at large that inadequate progress is being made in advancing the cause of safety, it certainly holds promise of a greatly accelerated rate of progress that all the most important organizations engaged in this field have agreed upon the program most needed and have joined their efforts toward the common end of making the program effective upon a national scale. The effort of this paper therefore is to reduce to concrete terms the necessary steps to be taken and in so far as possible to suggest the responsibility of initiation of the component parts of the program. Only by action on a national scale can even reasonable progress be made in the reduction of accidents, and in the freeing of our streets and highways from hazards that will permit the enjoyment of their convenience and service.

An 8-Point Program Submitted

To carry into effect the existing knowledge in the field of accident prevention, the following eight-point program is submitted. It is not intended to include all of the steps that will be necessary but it does provide a sound foundation for traffic control and regulation in the interests of traffic safety. Neither are the elements of this program independent but on the contrary they are inter-dependent, and to an extent overlapping. Several of these which are important parts of others are given individuality for the purpose of emphasis. The action program recommended follows:

1. Uniform State Motor Vehicle Traffic Laws.
2. Skilled Investigation of Traffic Accidents.
3. The Establishment of a Uniform System of Accident Reporting.
4. The Establishment of an Adequate Highway Patrol Including the Official Inspection of Vehicles.
5. The Establishment of Complete and Final Authority Over the Issuance and Revocation of Drivers' Licenses.
6. A Highway Improvement Program Divided Into Two General Classes of Projects:
   (1) Those of the emergency type, and
   (2) Those for the long-time plan.
7. A Plan of State and Federal Safety Organization Adequate to Secure on a Wide Scale the Adoption and Enforcement of the Action Program Here Proposed.
8. A National Educational Program.

The scope of each element of this program is indicated but not intended to be fully developed in this discussion.

1. Uniform State Motor Vehicle Traffic Laws

This subject has received long and careful attention. Through the organized effort of the National Conference on Street and Highway Safety a series of five proposed model laws were drafted and have been widely distributed. While a considerable number of states have adopted these laws in whole or in part there yet remains a serious non-uniformity in the major principles which affect highway safety. It is not proposed that the motor vehicle laws must be identical in every detail, but they must be in those matters which even remotely affect the safety of motor vehicle operation. The driving habits of individuals tend to become fixed, and particularly in times of stress or emergency the reactions are involuntary. Now that the traffic between communities and between states has become universal the necessity for replacing uncertainty of the law with certainy is self apparent. The necessity for drivers knowing that they do not face new traffic laws or conditions when they cross state borders cannot be denied. But the existing condition is much more serious than this as indicated in these examples:

Eight states do not require that all motor vehicle operators be licensed.

Two states fail to provide a minimum age limit for the driving of a motor vehicle.

Fourteen states permit the operation of motor vehicles by minors 14 or 15 years old.

Twenty-two states do not prohibit the issuance of drivers' licenses to habitual drunkards or narcotic addicts.

Twenty-four states do not prohibit the issuance of drivers' licenses to those afflicted with mental disabilities.

Only 11 states require drivers to be able to read highway warning signs printed in English.

In six states which do require the licensing of motor vehicle operators, no examination or test is included as a prerequisite to the issuance of such license, and in five others the applicants may be examined only when the official issuing the license suspects they are unfit to drive.

Only 30 states require every applicant for a driver's license to be examined for competency and in these the examination varies widely.

Only eight states require a test of vision, fifteen, a knowledge of traffic laws.

Unquestionably there should be a strict uniform license law issued only after a competent examination including tests of vision, ability to read traffic signs, knowledge of traffic laws and demonstration of ability to operate the vehicle.

In only 27 states has there been adopted a manual of uniform traffic control devices. The rules of the road governing the operation of vehicles upon the highway vary so greatly from state to state that confusion is inevitable. Nine states do not require vehicles to be driven to the right of the highway at all times. Six states do not provide that passing must be on the left of the overtaken vehicle. Passing on curves is specifically prohibited in 36 states and on the crest of hills in 35 states, at intersections with other highways in 34 states. The provisisions with respect to the equipment of motor vehicles and physical characteristics such as length, width, and height, have a wide variation with many inconsistencies.

Further discussion of this point is hardly necessary to indicate the fundamental necessity of a uniform motor vehicle law between the states in the interests of safety. The only possibility of providing for this part of the action program lies in the adoption by the state legislatures of the necessary uniform laws. A guide to the points of divergence from the uniform code will be found in the bulletin "Non-Conformity of State Traffic Laws" that will be available for distribution shortly by the Bureau of Public Roads.

2. Skilled Investigation of Traffic Accidents

An intelligent attack on the highway accident situation must depend upon two details which, while simple in concept, are not easy of achievement. There must be

information as to the circumstances under which each accident occurs, and there must be sufficient analysis to record where, and the manner in which, accidents are happening repeatedly. Accident data are essential to an intelligent and efficient police enforcement program within the urban districts, and the highway patrol can provide important information in the rural districts. Within the urban areas the establishment of especially trained squads is essential which are ready on call to investigate each accident without loss of time.

It may not be practicable at once to establish accident squads in the rural police organization sufficiently extensive to investigate all accidents, but it is possible to establish a number of special accident squads and to train each member of the highway patrol in the correct procedure to investigate and to report accidents so that a high general level of accuracy in reporting may be attained. So long as we depend for accident data on ex parte information and make inadequate provision for the securing of reliable and disinterested reports, just so long will our knowledge of the facts be insufficient and open to question.

It will not be possible to secure impressive accident reduction until it is recognized that every accident is the resultant of a number of causes and circumstances in the absence of any one of which the accident would not have occurred or would have had different consequences. No contributing cause is so unimportant that it may be overlooked or dismissed. That only a beginning has been made in this field in a very few States is convincingly revealed by the analysis presented in the case history of the fatal highway accidents now in process of publication by the Bureau of Public Roads. Certainly the establishment of a complete system of accident investigation and reporting will require much more adequate organization than now exists, but the cost will be small in comparison with the losses in life and proprty.

3. The Establishment of a Uniform System of Accident Reporting

The uniform reporting of accidents is partially covered by the preceding discussion, but requires in addition the adoption of a national standard form. Much work has been done upon the formulation of such a form by the National Safety Council, the Bureau of the Census and others, and further work is now in progress. It is essential that the terms be clearly defined, and the statistical methods employed give accurate results. In the studies made by the Bureau of Public Roads and the Highway Research Board, the lack of accurate and sufficient statistical data relating to accidents, even those involving fatalities, was an insuperable obstacle in the production of a more determinate report. For example, the national reports of motor vehicle fatalities are divided between urban and rural on the basis that urban accidents are those in cities of 10,000 and upwards, and all others are classified as rural. Taking into consideration the fact that a very large per cent of the total population lives in places of, say, 1,500 to 10,000 people, it is inevitable that a large percentage of fatalities reported in the rural category actually involve urban and not rural conditions. This probable discrepancy is further accented by the fact that so large a percentage of fatal accidents involve pedestrians. It is apparent that effective efforts to combat accidents are utterly dependent upon accurate and complete statistical data.

4. The Establishment of an Adequate Highway Patrol Including the Official Inspection of Vehicles

In most of the States the highway patrol organization for the rural districts, and in most of the cities, the traffic police, are wholly inadequate in numbers and equipment to patrol the mileage over which there is appreciable traffic. This condition of inadequacy in numbers is further aggravated by the addition of so many miscellaneous duties that too little time is left for patrol work. The most complete code of motor vehicle laws is of little avail unless there is proper enforcement. An increase in the number of trained patrolmen in every State is necessary.

Only 23 States now provide for the periodical inspection of motor vehicles, but all of these do not include all types. The inspection laws vary in detail but are uniform in the attempt to prevent the operation of mechanically defective vehicles. The establishment of inspection requirements for the safe mechanical condition of motor vehicles and their continuous enforcement is an important "must" in the action program.

5. The Establishment of Complete and Final Authority Over the Issuance and Revocation of Drivers' Licenses

In the development of this discussion, the importance of the official charged with the administration of the motor vehicle laws must be more and more apparent. The lack of essential laws in a large number of States fixing the qualifications of those who are permitted to operate motor vehicles upon the public ways has been recorded. The disclosures in the bulletin upon the accident-prone driver sustain the conclusion that the motor vehicle administrator must have authority to suspend or revoke the license of operators, and that this power must be exercised. The discretionary authority to revoke licenses should by law be obligatory action in the more serious offenses. Thirty States now require that a license be revoked for conviction of manslaughter, 36 States, for driving under the influence of intoxicants, 31 States, for failure to stop after an accident, and 25 States, for reckless driving. Certainly these offenses justify the revocation of licenses in each State. But the fact of the existence of the accident-prone driver, which is now established beyond reasonable doubt, justifies the suspending or revoking of licenses for much less grave offenses than these enumerated. Twenty-three States have recognized this by providing discretion to suspend or revoke for habitual recklessness or negligence, 22 States provide the same discretionary authority to revoke the license of drivers involved in a serious accident, and 11 States for any sufficient cause. The recognition of the responsibility resting upon the individual driver for accident prevention so far outweighs any other consideration that a sound action program must include as the most effective weapon of society in attacking the problem of accident prevention, the generally exercised power to revoke drivers' licenses for infraction of the traffic laws.

6. A Highway Improvement Program Divided Into Two General Classes of Projects: (1) Those of the Emergency Type and (2) Those for the Long-Time Plan

This year the State-wide transport surveys carried on in cooperation between the State highway departments

and the Bureau of Public Roads will begin to reach usable form. There will be available for the first time in any State complete information as to the types and conditions of highways, the amount and character of use and all other information which can conceivably have a direct relationship to the safe use of the highways.

The extent to which highway conditions enter as a contributing factor into more serious accidents is unknown and to an extent indeterminate. Much that has been said in criticism of highway conditions confuses the fundamental issues of highway safety and highway capacity measured by speed and number of units. Between 1925 and 1936 highway usage measured in terms of gasoline consumption increased by an estimated amount of 110 per cent, while registration in numbers of units increased 42 per cent. The gas consumption per registered vehicle has increased just under 50 per cent. From these facts it is apparent that motor vehicles are being used on a steadily increasing rate per average unit, and even with these increases the rate of accidents measured in miles of vehicle operation shows a decrease.

With the definite facts of the public use of highways in every community of the nation, it is readily apparent that the providing of safer highways must be through the elimination over large mileages of those conditions which to the best of our knowledge are most likely to be contributory factors in accidents. This is the keynote to the emergency program which should be put into effect determined by the data of the transport surveys.

As an illustration of the type of work included—a re-checking of the system of warning signs and signals, the relocating of these to fit the generally increased speed, the elimination of unnecessary signs, the marking of all curves with safe driving speeds if below the legal limits, the correction of sight distances, particularly at intersecting roads, and the widening and maintenance of shoulders. The increased operating speeds demand wider roads and the narrower widths which were reasonably safe for speeds of a few years ago must be supplemented by non-skid material, the shoulders widened, slopes flattened and deep ditches eliminated.

For the long-time program, particularly for new multiple lane roads, all the accepted elements of safe design to permit continuous safe traffic flow, including the division of opposing lanes by a neutral area and the elimination of cross traffic, should be provided. Separation of grades between the railroads and important intersecting highways must be a first consideration.

7. A Plan of State and Federal Safety Organization Adequate to Secure on a Wide Scale the Adoption and Enforcement of the Action Program Here Proposed

Just how the Federal Government fits into the general scheme of an adequate traffic safety organization is not clear beyond debate, but there are considerations of public policy which prompt the suggestion that no wholly new board, commission or other Federal authority is desirable. To be effective, such a Federal organization would have to duplicate organization, authority and operations now lodged in some Federal department. There is need for a correlation of the Federal activities and relationships between the Federal departments themselves and between the Federal Government and the States in both the official and public aspects. A plan of Federal organization that can be made effective at once and make use of the going operations of the Government would be the establishment of an inter-departmental committee with representatives assigned from all of the Federal organizations which now have authority over, and responsibility for, elements of the safety problem under the Federal laws.

In addition to this official organization there should be an advisory committee composed of representatives of the important national associations which are engaged in the traffic safety field in its broad aspects. This plan, together with the plan of organization of the State safety authority, would form a complete national structure for the formulation of an adequate nation-wide program and its effective operation.

8. A National Educational Program

One of the most assuring steps that have been taken in the field of education is the action by the National Education Association and the American Association of School Administrators to prepare a yearbook on safety. This important undertaking will be supplemented by various bulletins and other useful material to be distributed to all the public schools of the country to serve as a background for sound safety instruction to school children. Too much emphasis cannot be placed upon the importance of this whole activity.

One of the most valuable contributions to a permanent safety program which will doubtless result from this organized study by the educators will be an evaluation and decision as to the supplementary safety activities which should be undertaken or continued on an even broader scale in connection with the public schools. One of the greatest hopes for improved safety conditions lies through the implanting of correct thinking and habits in those who are now passing through the public schools. Illustrative of these supplementary activities are the driver training and school patrol sponsored by the American Automobile Association. In addition, a widespread program of public education and of specialized training of traffic officers and engineers is under way by national organizations through funds provided by the Automotive Safety Foundation. This list of organizations is a notable one, and has been mentioned in connection with the formulation and recommendation of a safety program for each State.*

Every indication points to progress during the coming year in the safety movement far beyond that made in any previous year, but the concept of adequate governmental organization and comprehensive laws must be the objective continuously recognized as fundamental in the establishment of a permanent safety program.

Acknowledgment—The foregoing is a paper presented Jan. 17 at the 35th annual convention of the American Road Builders Association.

*These organizations include the following: American Automobile Association, American Legion, Automotive Safety Foundation, General Federation of Women's Clubs, Harvard Bureau for Street Traffic Research, Highway Education Board, International Association of Chiefs of Police, National Automobile Dealers Ass'n, National Congress of Parents and Teachers, National Grange, National Safety Council, Northwestern University Traffic Safety Institute.

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MINNESOTA HAS 118,330 MILES OF ROADS—Statistics collected by the Minnesota State Highway Department show there are 118,330 miles of highway in the state, distributed as follows:

	Miles
State operated trunk highway system	11,353
County roads	37,448
Township roads	69,529

LIGHTING AND THE MODERN HIGHWAY

By EDWARD M. RICE

Street and Highway Lighting Safety Bureau
New York, N. Y.

HOURS no longer make a great difference in our routine of life. Night time has become almost as busy as the day. The touch of a switch floods with light. Home, movies, night sports, city streets, shops: a hundred places to go and a hundred things to do. Light everywhere, except on the highway—the one place where it is really a matter of life and death. We go blithely at night, tearing along at 50 and 60 miles an hour in modern cars on modern roads and in comparative darkness. As far as lighting goes, the highways today have advanced little from those over which the coaches rattled from Boston to Worcester a hundred odd years ago.

Probably one difficulty is that we have not bothered to question specifically what a highway should be. We have been content in some respects to accept what a highway is. Actually it is an area designed not simply to provide a means for motor travel but to provide safe and convenient travel. It would be difficult to describe the highways today as safe when one is faced with the perennial tragedy of traffic death, for the blame cannot all be laid at the feet of the motorist. He can't be taught to see in the dark.

Safety promotion has been effective in a specific area. Along with the improvements in the automobile and in the technique of road construction and planning it has brought a decline, continuing over a considerable period, in the rate of day fatalities—but the rate of night fatalities has continued to skyrocket. The clue leads back to the failure in the past to scrutinize carefully enough the available facts.

Traffic safety is not a uniform problem. It is divided sharply into two specific and radically differing phases—Night traffic safety and Day traffic safety. Take the fatality figures for 1937. Of the 39,700 people killed, about 23,800 or 60 per cent were killed after dark, when only one out of every four or five cars was on the road. That brings up the question, why this astonishing difference in experience?

It cannot be explained by traffic densities, for only one-fifth to one-fourth as many cars are on the road at night as in the daytime. Incidentally, too, there are about 760 more daylight hours in the course of a year than there are those of dusk or darkness. It is impossible to escape the fact that the only major variable which can explain the great difference between night and day experience is *illumination.*

In the daytime a driver has anywhere up to 10,000 foot-candles of natural illumination. At night he has practically no illumination at all. In conseqence, automobiles carry headlights which provide, at 150 ft. a fraction of one foot-candle.

Look at it this way: analyze the records from 1917 to 1937. In 1917, night fatalities represented only 30 per cent of the 24-hour total. Since then, they have increased to over 60 per cent. In 1917, 4,983,000 cars drove an average of 3,000 miles, or a total of about

Traffic Circle, Latham's Corners, Near Troy, N. Y., Illuminated with Sodium Highway Lighting Lamps

15,000,000,000 car-miles. Then there were some 300,000 miles of surfaces highway and the average speed was about 25 miles an hour. In 1936, 28,270,000 cars traveled an average of close to 8,000 miles per car, or a total of more than 218,000,000,000 car-miles. Surfaced roads had increased to about 1,000,000 miles, and 55 miles an hour was a common speed.

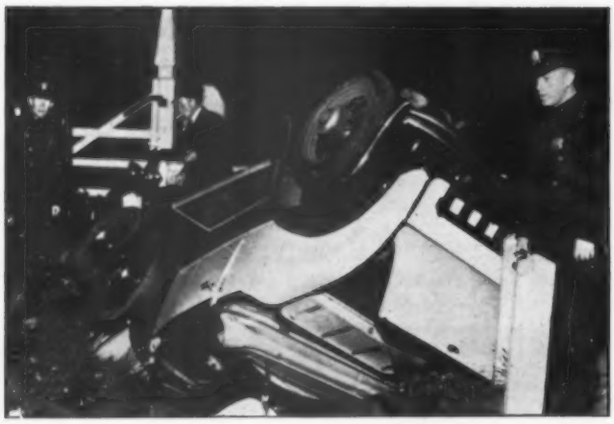
Over that peroid registration increased 600 per cent, average mileage per car 125 per cent, total annual mileage 1,300 per cent, average speed 100 per cent, miles of surfaced roads 300 per cent.

In consequence, it would be only natural to expect some of the increases in traffic accidents that occurred over that period, but those increases should have been indicated in the same relative degree in both night and day rates. They weren't—night accidents more than doubled in comparison.

The physical facts contributing to safer driving have kept pace with those other factors, contributing to the danger of driving. Automobiles have been improved not only in comfort, efficiency, and styling, but in the safety that has been built into them. Highway construction and planning, and traffic methods have advanced likewise. And all to the point where —coupled with the promotion of safety education—fatalities in the daytime have actually declined.

There is but one thing that has not changed at all in those years. The headlights of 1917 afforded about 150 ft. of visibility. The headlights of 1938 afford just about the same amount. However, the light that was available for night driving in 1917, though bad, was closer to being adequate than the same amount of light is under conditions which exist today.

When you consider that at 55 miles an hour a car is traveling 81 ft. a second, and that the visible space provided by headlights is covered in less than two seconds, the night accident rate is not surprising. It



Overturned Open Automobile with Person Underneath. Careless and Poor Highway Lighting at Point Near New York, N. Y.

takes 150 ft. to stop at that speed. If the driver is lucky enough to see an obstacle, he might stop before he hits it. As a matter of record, fatalities are 100 per cent greater during the winter evening rush hours when it is dark than during those same hours of the summer when it is light.

There seems to be no other conclusion from a logical analysis than to accept the fact that adequate light is vital to safe night driving, and that just so long as we continue to drive modern cars over modern highways, under lighting conditions that are twenty years out of date, the rate of night traffic fatalities will continue to rise.

The development of lighting equipment and methods has not failed to meet the needs of the time: It is simply that they have not been put to use. The automobile public has not demanded it. Existing lamp equipment, either of the incandescent, sodium vapor, or mercury vapor type, can produce from 700 to 1,200 ft. of adequate visibility, and even that is none too much.

Permanent lighting functions on quite different principles from lighting with headlights. Instead of directing light away from the driver, light properly controlled is directed both toward and away from the driver; instead of producing a limited spot of light, a uniform surface brightness along the entire course of the road is produced; instead of effectuating visibility by reflected light, as with the headlight, seeing is produced by silhouetting objects, or really by a combination of both. Instead of depending on 28,000,000 different automobile owners for its adjustment and maintenance, as does the headlight, highway lighting as a permanent installation keeps a constant efficiency, and its maintenance is the responsibility of a relatively few officials. Not only does it eliminate glare; it completely does away with the blinding effect of headlights, even at full brightness. In fact, the use of headlights is not essential on lighted stretches.

No argument for highway lighting should ever be construed—though it often is—as an argument against headlighting. The latter is obviously essential, and always will be, for the lighting of all or even an appreciable percentage of our roads is certainly not within the vision of our time. The only proposal that is being put forward by any responsible organization or individual relates only to those highways or zones which can be defined as "Ultra-Hazardous Night Mileage" or "Night Accident Zones"—sections of highway or specific locations where the night fatality rate is radically out of proportion to the day rate. Probably less than two per cent of the roads of the country fall within this classification.

So headlighting is not only necessary, but it must be improved if it is to do an effective job on the millions of miles of highway that will never be illuminated. And there have been for some time rumors that the near future will see improvements and changes in the lighting equipment on automobiles.

It is difficult to give specific lighting cost figures, since they vary widely with the type of road to be lighted, with the locality and with the type of lighting used. Maintenance charges are equally difficult to quote for the same reasons; but it should be sufficient that, on the experience of actual installations, they represent a small fraction of the savings realized from reduction in personal and property damage.

Costs of installation are estimated to run from 5 per cent to 7 per cent of the original cost of the highway, and the maintenance charges have been found to average about one-third of the savings, resulting from the lighting, in property damage.

In reporting to the association, the problem committee on Highway Illumination of the American Road Builders' Association made the following recommendations:

First, that the association adopt as a fundamental part of its program the principle of increasing both day and night visibility on highways—(a) by eliminating curves and obstacles which interfere with daylight visibility, and (b) by installation of highway illumination to give day visibility at night.

Second, that the association vigorously advocate:

1. Installation of adequate highway lighting on heavy traffic highways connecting cities.
2. Similar lighting for new highways where there is a heavy traffic expectancy.
3. Installation of highway lighting on five or more mile stretches in other sections of populous states where traffic and accident records indicate lighting would prove beneficial.

Third, that the association of itself, or in cooperation with other national organizations, sponsor a fact finding program to include investigation of present and proposed highway lighting installations to obtain further information on—

1. Effectiveness of highway lighting as a means of preventing night traffic accidents and of increasing night traffic.
2. Cost of installation, operation and maintenance of lighting equipment.
3. Cost of traffic accidents and the value of more even distribution of the 24-hour traffic correlated with No. 2.

Fourth, that the problem committee on Highway Illumination be continued as the agency of the association to assist in carrying out these recommended plans.

Twenty-three thousand and eight hundred lives are nothing to pass over lightly—that is the approximate number killed after dark in 1937. More has got to be done to save some of those lives. The American motorist, if for no other reason than a financial one, is entitled to it for he pays annually close to $1,500,000,000 in gasoline and motor-vehicle taxes. About 25 per cent of that tax is diverted to non-highway use and at the same time the National Resources Committee reports to the President that at least 35 per cent of night traffic fatalities could be prevented by the provision of adequate highway illumination on the major, heavily traveled thoroughfares.

Fig. 1—View of a Slag Plant Showing Blast Furnaces in the Background, and Cooling Pits in the Center of the Picture.

PREPARATION AND PROPERTIES OF BLAST FURNACE SLAG

By D. G. RUNNER

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THIS article is one of a series dealing with the origin, composition and properties of various aggregates used in road building. The material to be discussed at this time is iron blast furnace slag. Its very name, "Blast Furnace Slag" designates the original source of production. It must be understood that while slag and pig iron are produced simultaneously in a blast furnace, in this paper iron will be mentioned only incidentally.

It has been estimated that during the past 30 years over 100,000,000 tons of slag have been used in various fields of the construction industry. Approximately 75 per cent of this amount was used in highways in 23 states whose highway department specifications now admit its use in construction and maintenance. The fact that its utilization has been restricted to territories relatively adjacent to its original points of production, and that its distribution is not of national scope, are the most important reasons why descriptions and data covering this aggregate should be of special interest to the engineering and construction fields of the entire country.

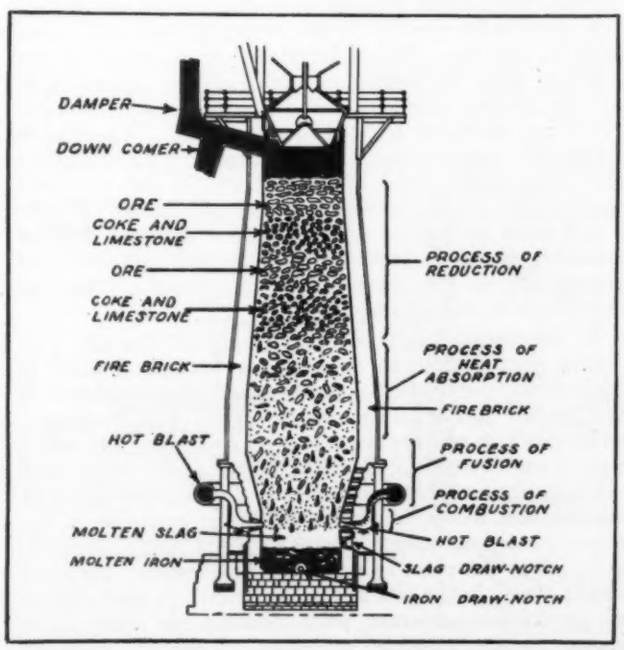

Fig. 2—Cross Sections of a Typical Blast Furnace, Showing the Raw Materials Placed in Layers.

Comparatively few engineers are entirely familiar with the method of production and the composition and properties of blast furnace slag. Therefore, the purpose of this paper is to discuss the material in all its phases from the time of the introduction of the raw ingredients into the furnace until it is discharged, has been cooled, suitably crushed and sized for use as aggregate accepted for various types of construction. These main topics will include the description of how slag is formed and processed, the various types of slags produced, as well as their physical, chemical and petrographic characteristics.

Enough data will be presented here to inform the reader in a general fashion of the more important details of manufacturing and processing of blast furnace slag, but obviously space limitation will prevent a lengthy discussion of each of the above items. Figure 1 is a view of a slag plant showing blast furnaces and cooling pits.

Definition and Method of Production

Blast furnace slag may be defined[1] as the non-metallic product consisting essentially of silicates and aluminosilicates of lime or other bases, which is developed simultaneously with iron in a blast furnace.

[1]Proc. Am. Concrete Institute, Pg. 524, 1925.

TABLE I—ANALYSIS OF IRON ORES FROM LAKE SUPERIOR AND ALABAMA REGIONS

(From Economic Geology, by H. Ries, John Wiley & Sons, New York.)

Lake Superior Region—	Iron	Silica	Sulphur	Phosphorus	Lime
Marquette	56.50	4.58	0.008	0.035	....
Menominee	55.24	6.75	....	0.059	....
Gogebic	56.30	3.39	....	0.033	....
Vermillion	61.36	4.25	....	0.037	....
Mesabi	56.09	3.48	....	0.036	....
Alabama—					
1	37.00	7.14	0.08	0.30	19.20
2	45.70	12.76	0.08	0.49	8.70
3	50.44	12.10	0.07	0.46	4.65
4	54.70	13.70	0.08	0.10	0.50

Reduced to its physical essentials a present day blast furnace is a hollow cylinder of steel plate about 100 to 125 ft. in height which is lined inside with a refractory material. It is approximately 25 ft. in diameter, although this dimension varies in certain cross sections. The lower part usually referred to as the hearth or crucible is about 12 ft. high and it is here that the molten slag and iron collect and are drawn off at intervals. Depending upon the size of the furnace, 40,000 to 75,000 cu. ft. of preheated air per minute is introduced into the furnace through openings equally spaced around the circumference of the crucible. This blast of air performs three major functions: the ore, fuel and flux are preheated; the metallic oxides in the ore are deoxidized or converted into metal; and the resulting iron and slag are produced. Carbon dioxide is driven off the flux by the heat of the combustion of the fuel, and the remainder of the solids combine with the dross of the ore to form the slag, leaving the metallic iron free. This fusion of the various elements (silica, manganese and sulphur) of the slag occurs at a point above the hearth where the temperature is about 3,500° F., or 1925° C.

In a blast furnace operation recently inspected by the writer, 1,000 lb. of slag are produced from 4,400 lb. of iron ore, 2,100 lb. of coke, and 1,200 lb. of flux stone (either limestone or dolomitic limestone). These figures may vary considerably from time to time and from various plant locations. These fluctuations depend chiefly upon the grade and type of iron ore used, although the flux and fuel also influence them. For example, about 1,000 lb. of slag per ton of iron is produced under average furnace practice by using Lake Superior ores, while with the leaner ores such as are used in the Alabama district more slag is produced per ton of iron. Reference to Table I will show the difference in the composition of the iron ores from the Lake Superior and the Alabama regions.

Fig. 3—View of Slag Being Discharged from Ladles. Note the Thick, Viscous Appearance of the Slag as It Leaves the Ladle.

Fig. 4—View of Top Surface of Cooled Blast Furnace Slag. The Texture Here Closely Resembles Molten Lava.

Each ingredient included in the process of furnace operation (ore, flux, fuel, etc.,) is stored for convenient use closely adjacent to the furnace. As the units of the raw materials are taken from these stock piles, each is carefully weighed and placed in the loading apparatus. This container which is mounted on wheels, runs on nearly vertical rails to the top of the furnace where its contents are discharged into the interior. The ingredients of the blast furnace burden are added as needed to keep the furnace fully charged at all times. Inasmuch as the operation of a blast furnace may be continuous over a period of several years, precision of physical, chemical and mechanical control of the raw materials as well as the finished products must be maintained at all times. Chemical analyses are made of the slag at frequent intervals throughout the entire run of the furnace, to check the composition.

After their being reduced to a fluid state, the difference in specific gravity of the slag and the iron causes them to separate. When "casting," or drawing off the iron and slag, the hearth is tapped at the "iron notch" and the molten iron is allowed to run through troughs into large ladles of 10 to 12-ton capacity. The slag is drawn off from a "slag notch" located at a point slightly above the level of the iron notch and is also run into another set of ladles mounted on railroad trucks. Figure 2 is a cross section of a blast furnace showing the raw materials placed in layers. In some few instances, the molten slag is run directly through troughs from the slag notch to the cooling pit.

In the earlier days of American blast furnace procedure, the production of slag was usually hauled to land closely adjacent to the furnace that produced it and heaped into small mountains merely as a waste material to which no care nor attention was given and which was often contaminated with debris from other steel plant operations. At most points of production of commercial slag today, however, the direct opposite of the above conditions prevail and every precaution is rigidly enforced in the plant to make certain that only the clean slag is placed in the pits or on the banks. At many points of production concrete walls confine the material to insure against possible intrusion of foreign materials until the accumulation is drawn on for further processing in the crushing plant.

Fig. 5—View of Air-Cooled Slag, Showing Stratification.

Major Types of Slag

Depending on the results obtained by treating the molten mass after its withdrawal from the furnace, slag may be divided into two major classifications namely: air-cooled and granulated. Whether slag is manipulated to produce either of these types, its chemical composition remains the same. The real difference between air-cooled and granulated slag is purely physical. The former is the tempered product produced by relatively slow cooling, in decided contrast with the shattered mass obtained by the rapid chilling.

Air-Cooled Slag—The initial processing of air-cooled slag may be by one of three common systems or methods. In the "pit system," the slag flows through runners or trenches direct to small pits alongside the furnace, from which it is regularly excavated. In other methods, the molten slag is poured into large ladles and conveyed to a point at some distance from the furnace, where it is either poured over a very large plot of land with no definite attempt to control width or depth, known as the "bank system"; or is discharged into large, well-defined pits served by permanent trackage, from which it is regularly excavated,—this being known as the "modified pit system." Fig. 3 shows molten slag being discharged into pits, while Fig. 4 illustrates typical surface after cooling.

The successive superimposed pourings in any of these methods result in stratification (See Fig. 5) in the solidified material which readily breaks into roughly cubical pieces when removed by a power shovel. The broken slag is conveyed by small cars to the crushing plant. Here the processing includes primary crushing, screening, secondary crushing, free iron removal by powerful magnets and the final sizing. Fig. 6 is a characteristic flow diagram. The screened material is stored in bins, or in stock piles, adjacent to transportation facilities. Fig. 7 illustrates crushed slag.

There are two mineralogical terms occasionally used in classifying air-cooled blast furnace slag. These depend upon the chemical compounds present in the sample. The term "acid slag" is used when there is a preponderance of alumina and silica in the sample over the other constituents. Acid slags are usually dark in color and are slow to crystallize during cooling due to the high silica content. A "Basic slag" is one in which there is a preponderance of lime and magnesia compounds over the remaining constituents. Basic slags crystallize more readily than acid slags, and in addition are lighter in color.

Granulated Slag—Granulated slag may be defined as the product resulting from the very rapid chilling obtained by running molten slag directly into a tank or pit partially filled with water. The greater portion of the resulting product is composed of light, fluffy and cellular particles combined with those that are slightly more dense. Though its color varies from grey to light yellow, the particles composing the mass do not look unlike popped corn. Owing to the great porosity of much of the material, it will float until it becomes saturated. Only the denser particles settle at once to the bottom of the tank.

Other Types of Slag

Agricultural Slag—This is usually granulated slag in sizes from ¼ in. to dust, which is mixed with the soil for the purpose of aeration and neutralizing naturally occurring acids.

Pancake Slag—This is a term applied to slag cooled in a machine similar to a pig casting machine. In this process, the slag is cast in large flat molds about 20 by 45 ins. and 2 ins. deep. These pans of slag travel along an endless chain conveyor, and when within a short distance of the discharge point, the cooling is hastened

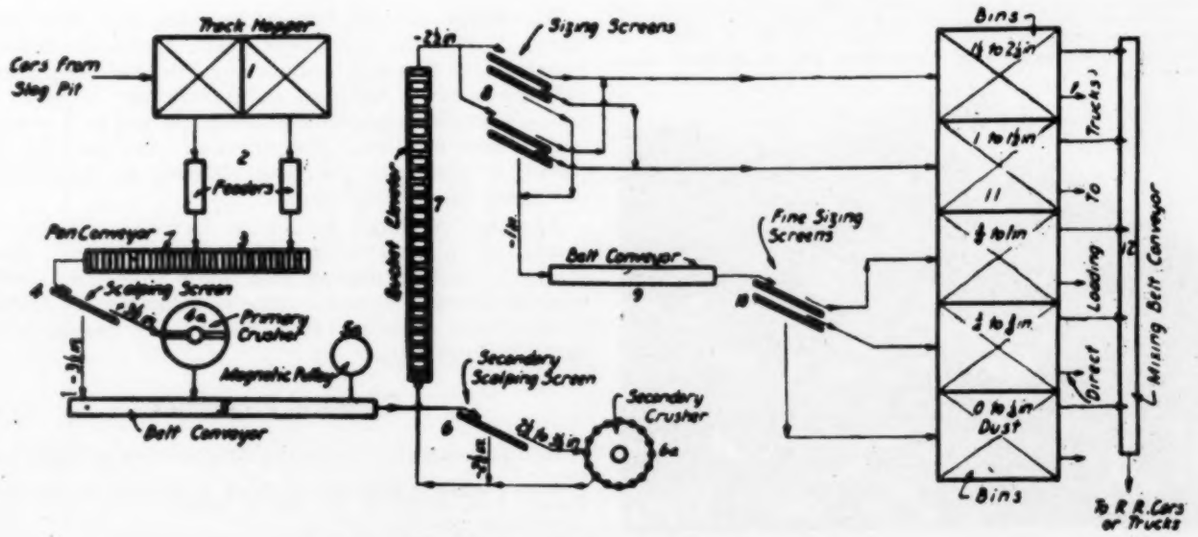

Fig. 6—Flow Diagram of a Typical Slag-Crushing Plant.

by sprinkling with water. This cracks the slag and the subsequent drop into the car breaks it into small pieces.

Waylite—This is a trade name for slag aerated by a special process and is distinctly light in color.

Tuff-Lite—This is a trade name for a specially granulated slag formed in a large cellular mass and subsequently reduced to desired sizes.

Pottsco—This is a trade name for a modified granulated slag.

Physical Properties of Slag

Weight Per Cubic Foot—This determination is usually required by specifications, for use in various types of construction. It appears from past observations and results of extensive test programs that the unit weight of slag is a better indicator of quality than any other specification requirement. The difference is that the apparent specific gravity of the various particles of slag affects the weight per cubic foot. Slag, in general, is comparatively constant from a standpoint of actual weight of the solid portions. It may be readily seen that the vesicular structure in addition to the grading may have an effect upon the weight per unit volume. Hubbard has shown[2] that the unit weight of sixteen commercial slags ranged from 75 to 101 and averaged 87.5 lb., while symposium No. 14,[3] reports that over a two-year period the unit weight of dry, rodded slag from 44 sources averaged 80.0 lb. The unit weight of granulated slag runs considerably under the 70-80 lb. classification for air-cooled slag. Figures from Symposium No. 14 of the National Slag Association show the unit weight of granulated slag to range from 44 to about 60 lb. per cubic foot. On close observation of numerous slag particles, variations in the pore structure will be noted to range greatly in size. In some instances the appearance is sponge-like, while in others, the pores are so minute that the surface appears smooth and vitreous.

Specific Gravity—The apparent specific gravity of air-cooled slag, as determined by standard methods, averages about 2.25. However, some slag samples may range from 1.80 to 2.80 depending upon the cellular structure and mineral composition of the slag. The apparent gravity is determined on slag particles containing pore space, while the true specific gravity is made on the powdered material by which method the pores are essentially eliminated. The true specific gravity of slag ranges between 2.90 and 3.10. Harsch in his investigation of 28 slag plants in 1919,[4] found the average specific gravity to be 2.11, while Hubbard,[5] reports the average gravity of sixteen commercial slag samples as 2.30.

[2]Studies on Relation Between Characteristics of Blast-Furnace Slag and Other Coarse Aggregates and the Properties of Resultant Concretes, by Fred Hubbard, Proc. ASTM V. 36, Pt. I, 1936.

[3]Physical Qualities of Slag, Symposium No. 14, National Slag Association, March, 1929.

Fig. 7—View of Macadam-Size Blast Furnace Slag.

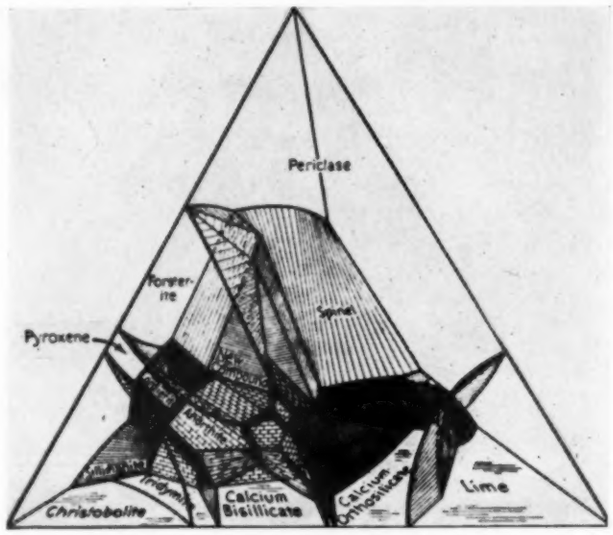

Fig. 8—Model Showing Spaces of Composition of Primary Crystallization of a Blast Furnace Slag (After R. S. McCaffery).

Absorption—The ability of a mineral aggregate to absorb water is a matter of importance in many ways. If the material is to be used in a designed mix of concrete, the amount of water taken up by the aggregate must be known in order to compute the quantity of mixing water required. Harsch, in his study of slags,[6] shows the average absorption of twenty-eight different samples to be 3.80 per cent, while Hubbard[7] in his paper states that the total absorption of 16 commercial slags was 2.90 per cent.

Per Cent of Wear—Regarding the abrasive loss of air-cooled slag, Symposium No. 2 of the National Slag Association, states the per cent loss by Deval abrasion averages 13.7 for 200 samples selected from 16 slag plants over a one-year period. Harsch and Hubbard show average losses of 15.5 and 10.6 respectively in their work on blast furnace slags. Reference to Table II will show average values obtained from different sources.

Durability—In the laboratory, slag has been subjected to various soundness tests, including boiling, freezing and thawing, sodium sulphate and magnesium sulphate tests; it has also endured nearly 30 years of nature's attacks winter and summer, in use as a sewage trickle filter medium. The effect of the tests and exposure is practically nil, slag showing no measurable indication of disintegration.

Although produced in a blast furnace, slag consists chiefly of minerals commonly associated with those found in molten magma emanating from the earth's interior forming igneous materials located in certain areas of the world's crust. Slag closely resembles its natural counterpart.

Chemical Properties

In discussing the chemical characteristics of blast fur-

[4]Blast Furnace Slag as an Aggregate in Concrete, by Raymond Harsch, Proc. ASTM, V. 23, Part II, 1923.

[5]Hubbard, Loc. Cit.

[6]Harsch, Loc. Cit.

[7]Hubbard, Loc. Cit.

TABLE II—PHYSICAL PROPERTIES OF BLAST FURNACE SLAG

Source	No. Tests	Wt./Cu. Ft. Compact	Apparent Sp. Gr.	Absorption Pct. by Wt.	Pct. Wear Std. Meth.	Voids Compact
Harsch	28	...	2.11	3.80	15.5	...
Rea	40	...	1.86	10.72	15.4	...
Hubbard (1936)	16	87.5	2.30	2.90	10.6	39.0
Abrams	21	88.0	2.26	....	...	...
Freeman	9	74.0	...	....	...	...

TABLE III—CHEMICAL COMPOSITIONS OF SLAG

Source of Information	No. of Samples	Oxides SiO_2	Al_2O_3	CaO	MgO	S	FeO	MnO
Harsch	29	35.92	14.68	38.14	5.25	1.43	1.51	0.61
Freeman	9	34.44	12.74	39.25	9.49	1.39	0.94	0.47
Hubbard	191	36.44	12.73	41.28	6.50	1.46	0.78	0.85
Lord	14	36.70	12.48	38.77	6.15	2.94	0.81	0.60
Nat. Bur. Stds.	8	37.91	13.68	33.84	9.64	1.36	...	...
Carnegie Steel Co.	5	33.89	16.97	41.89	2.13	1.42	3.27	...
Hubbard	16	37.82	12.79	40.16	7.28	1.00	...	0.41
Comm. C-9.... (ASTM)	20	36.71	12.85	40.03	7.67	1.09	0.82	0.41
Grand source avg.		36.24	13.61	39.17	6.76	1.51	1.35	0.56

nace slag, Committee 201 of the American Concrete Institute[8] states that:

"Chemically, blast furnace slag is made up of calcium oxide (CaO), alumina (Al_2O_3), silica (SiO_2), and magnesia (MgO); there are also small quantities of iron oxide (FeO), manganese oxide (MnO) and sulphur compounds. The chemical composition is entirely dependent upon the nature of the materials charged to the furnace—the lime and magnesia in the flux stone, the alumina and silica in coke and ore."

A relatively high variation in the amount of magnesia in slags is due generally to the use of dolomites as the flux, instead of limestone. Reference to Table III shows the difference found in the oxide compositions of various slag samples. This variation is to be expected since the ultimate composition of the slag is wholly dependent upon the character of raw materials charged to the furnace.

After the iron is extracted from the ore, the remaining material (except that part which passes off as gases) combines with the flux stone and the residue from combustion of the coke, and forms the slag. The variation in chemical composition of the iron ores, for example, those from the Lake Superior region and Alabama, or New York, may also have some effect upon the resultant slags formed. It might be interesting to show where the compounds (shown in Table III) originate.

Compounds	*Origin*
Silica	Ore, coke
Alumina	Ore, coke
Lime	Flux stone
Magnesia	Flux stone
Iron	Ore
Metallic iron	Ore, molten metal
Sulphur	Ore, coke
Manganese	Ore

Regarding the use of flux stone, Camp and Francis[9] state:

"Referring to limestone and dolomite as blast furnace materials, there is a difference of opinion among furnace men to their relative value as fluxes. Some hold that limestone is the better, while others maintain that dolomite gives as good, if not better, results, their opinion being influenced by their training and by the extent of their experience with these materials. The presence of magnesium in limestone in small amounts has little effect, but as the content increases, it may lower the fusion point of the resultant slag by the formation of double salts. A high percentage (over 3 per cent) of magnesia in blast furnace slag renders it undesirable for

[8]Blast Furnace Slag as Concrete Aggregate, Journal American Concrete Institute, V. 27, 1930.

[9]The Making, Shaping and Treating of Steel, by J. M. Camp and C. B. Francis; 2nd Ed., 1920.

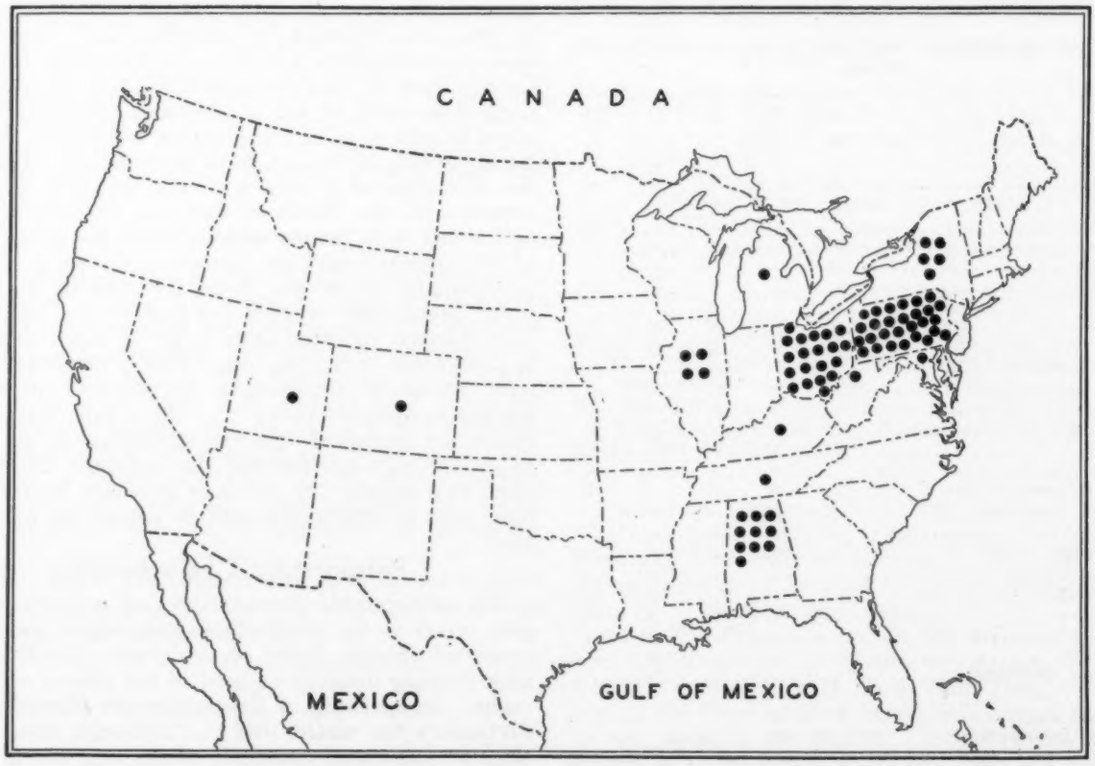

Fig. 9—Map Showing Distribution of Slag Plants by States.

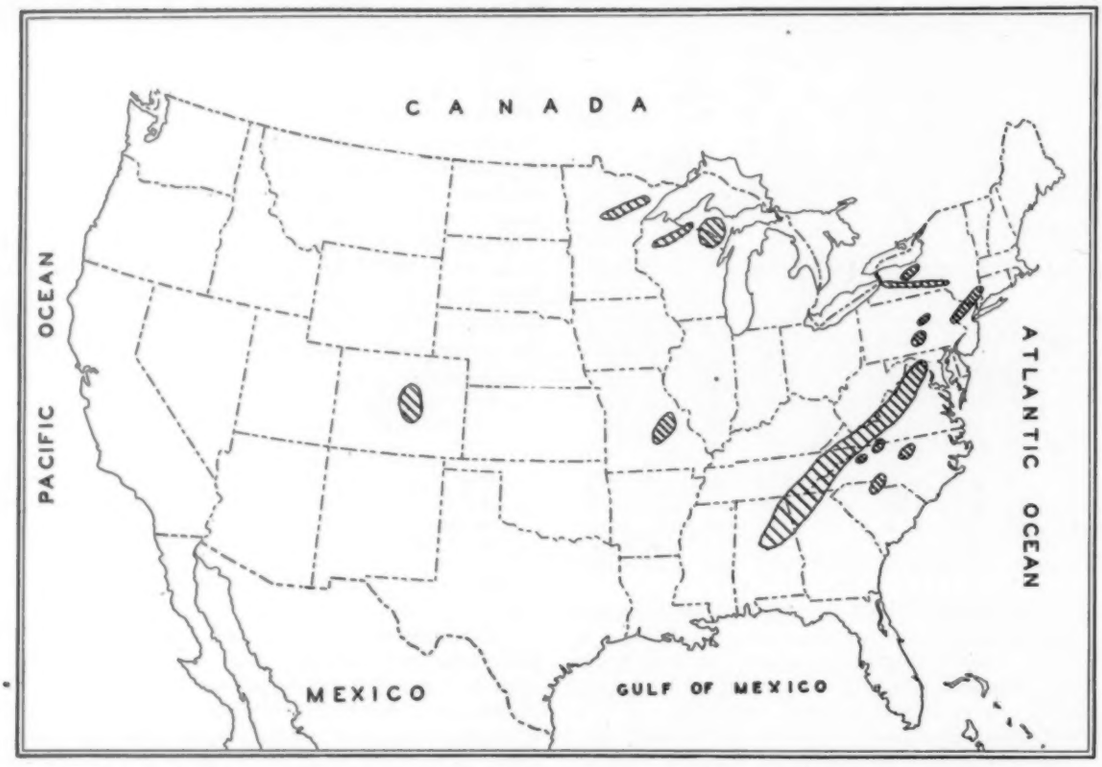

Fig. 10—Map Showing Approximate Location of Hematite and Magnetic Deposits in the United States. (Based on a Map After Harder, U. S. G. Survey, Mineral Resources, 1908.)

cement, but for concrete (aggregate), ballast, etc., it is desirable as it makes the slag harder (tougher)."

Bowles,[10] in discussing fluxing reagent, states that, "The chief impurities in most iron ores are silica and alumina, and the addition of a basic flux is necessary to form a slag. If iron ore were reduced without flux, the siliceous and argillaceous gangue would unite with the iron oxides to form double silicates of iron and alumina, which would involve a heavy loss of iron. With the addition of limestone, the silica and alumina have a stronger affinity for the lime and magnesia than they have for the iron, and in consequence double silicates of lime and alumina or magnesia and alumina are formed—compounds which contain very little iron. . . . Coke is used as blast-furnaces fuel, and when it burns varying amounts of ash are formed. The ash is composed largely of silica and alumina, which, like the similar impurities in the ore, must be removed. Therefore, the formation of a slag with the ash is a secondary function of the limestone flux. . . . Another purpose of the flux is to remove sulphur from the metal. Most of the sulphur enters the furnace in the coke, but there is a transfer of sulphur from the coke to the sponge iron. Metal, even when it has reached the bosh of the blast furnace, often contains twice as much sulphur as is permissible in the pig iron. Proper additions of flux with necessary temperature adjustments reduce the amount to specified limits. . . . As a rule, high-calcium fluxes are preferred, but the difference in action between the high-calcium and the dolomitic fluxes is so small that usually the choice is governed by other factors, such as availability, cost or percentage of impurities."

[10]Metallurgical Limestone, by Oliver Bowles, Bull. 299, U. S. Bureau of Mines, 1929.

TABLE IV—MINERALS FOUND IN BLAST-FURNACE SLAG

Item	Source A	B	C	D	E*
Lime	×	..	..	..	..
Anorthite	×	..	×	×	..
Periclase	×	..	×	×	..
Forsterite	×	..	×	×	..
Pyrozene	×	..	×	..	..
Cordierite	×	..	×	..	..
Sillimanite	×	..	..	..	..
Cristobilite	×	..	×	×	..
Tridymite	×	..	×	..	..
Gehlenite	×	×	×	×	×
Spinel	×	×	×	..	..
Calcium bi-silicate	×	..	..	..	..
Calcium ortho-silicate	×	×	..	..	..
Glass	..	×	..	..	..
Akermanite	..	×	×	×	×
Olivine	..	×	×	..	×
Melilite	..	×	×	..	×
Ortho-di-silicate of lime	..	×	..	..	..
Ferrite of magnesia	..	×	..	..	..
Mullite	..	..	×	..	..
Monocalcium silicate	..	..	..	×	..
Dicalcium silicate	..	..	..	×	..
Dlino-enstatite	..	..	..	×	..
Diopside	..	..	..	×	..
Madisonite	..	..	..	×	..
Monticellite	..	..	..	×	..
Tricalcium disilicate	..	..	..	×	..

*German slags.

Source of Information:

A—R. S. McCaffery. B—Dr. E. C. E. Lord. C—Committee 201, American Concrete Institute. D—L. A. Dahl. E—Dr. A. Guttman.

Petrographic Characteristics

The petrographic characteristics of a mineral aggregate refers to the composition with regard to minerals contained therein, based on a definite classification of rock-forming minerals as used in the science of petrography. In speaking of the compounds formed in slag, McCaffery has stated that [11], "Although blast-furnace slags are composed ultimately of the four constituents—

[11]Constitution of Blast Furnace Slags, by R. S. McCaffery, The Iron Age, Oct. 30, 1924.

silica, alumina, lime and magnesia, they are actually composed of compounds of these substances, some of the compounds containing two, some three and some four of these ultimate constituents. In all, there are 17 compounds of silica, alumina, lime and magnesia that enter into the composition of slags, in addition to the ultimate constituents themselves, or 21 in all, so that actually any slag may contain one, two, three or four of these compounds of ultimate constituents. . . . The system of four components, the sum of which is 100 per cent cannot be represented by drawings on a plane, so that it was necessary to construct space models. . . . The complete model (see Fig. 8) shows the spaces of composition of primary crystallization, and from the location of the interior tetrahedra faces the approximate mineral composition of a slag of any composition can be determined."

The report of Committee 201 of The American Concrete Institute (referred to earlier in this paper) states that petrographically slag is composed mainly of dicalcium silicate and calcium aluminosilicate, as well as melilite, periclase, spinel, forsterite, pyroxene, cordierite, mullite, cristobalite, tridymite, anorthite, gehlenite, olivine and akermanite. So many different minerals have been stated to occur in blast furnace slags, that some of the available data bearing on this phase have been put into the tabular form as shown in Table IV. Reference to this table shows that a number of the minerals, periclase, pyroxene, olivine, and others to have been found by all the investigators mentioned.

It is realized the study of slag by petrographic or physicochemical means is a separate study in itself, so that no further attempt will be made here to discuss this feature.

Geographic Distribution of Slag Plants

As a matter of general interest, and to show the geographic distribution, plants producing (crushed and screened) blast furnace slag are plotted by States on the map shown in Fig. 9. Iron ore deposits are shown on the map in Fig. 10 since these govern the source of supply for the slag plants. By virtue of the natural occurrence of iron ores, flux material and fuel deposits, the principal iron production is located in the Eastern half of the United States, and in general centers conveniently near the Lake Superior, Pennsylvania and Alabama regions.

Conclusion

In summation, it is hoped that this brief discussion of blast furnace slag will enable the engineer to appreciate and to understand the production, preparation and properties of this material. Its registered characteristics, such as texture, density, and constitution, make it suitable for many purposes such as filter beds in sewage works, railroad ballast, and as concrete and macadam aggregate. In fact, the chemical and petrographic characteristics of slag cause it to be compared favorably with aggregates produced from naturally occurring molten magma. In the following table are shown the chemical analyses of the slag samples shown in Table III of this paper, as compared with some typical analyses of gabbro, basalt and diabase rocks reported by Clarke in his "Data of Geochemistry":

	Material			
Oxides	Slag	Gabbro	Basalt	Diabase
SiO_2	36.24	55.40	48.76	49.64
Al_2O_3	13.61	15.32	15.89	15.07
CaO	39.17	9.90	8.15	7.23
MgO	6.76	5.75	5.98	5.43
S	1.51	....	....	....
FeO	1.35	5.49	4.56	8.82
MnO	0.56	0.11	0.13	0.25

In the above table a similarity between the analyses of the four materials is noted. The closest agreement is found to be between the silica, alumina, magnesia, and manganese oxides. It must be remembered that the fluxing reagent (mainly calcareous) is responsible for the higher lime content shown in the slag analysis, and this compound is accordingly much higher than would naturally occur in the igneous rocks.

The physical processes under which slag is formed are comparatively simple, but the physicochemical phase of its production is considerably more complex. It is proposed, in a later paper to discuss this phase as well as the petrography of blast furnace slag.

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▼

Professor Casagrande to Lecture at Illinois—The Department of Civil Engineering, College of Engineering, University of Illinois, Urbana, Ill., is sponsoring a series of lectures by Professor Arthur Casagrande. The dates and subjects of his lectures are: April 6, The Principles of Soil Mechanics; April 7, Recent Developments in Settlement Analysis; April 8, Recent Developments in Earth Dam Design. In addition to the three lectures in the field of soil mechanics, he will speak to the Student Chapter of the American Society of Civil Engineers on the New German Highways. All lectures are open to the public.

OBSERVATIONS BY THE WAY

By
A. PUDDLE JUMPER

¶ To keep contractors from cluttering up their steps while waiting for decisions on their loans a bank in

southeastern Oklahoma posted the notice shown herewith. What's happened to that pioneer Oklahoma spirit?

• •

¶ What do you think of this one? "Dear Sir—

The following question came to our library and we are under the impression you could answer it for us without doing any research work:

'Is it true that there are in the United States thousands of miles less of concrete roads in summer than in winter due to shrinkage of concrete?'

We thought you might be able to give us the approximate number of miles of concrete roads and the percentage of shrinkage between winter and summer.

Yours truly,
BLANK & BLANK, INC.,
MARY DOE,
Librarian."

There's a mathematical time-waster for you.

• •

¶ "Know Your Ropes" is the title of as good a discussion of wire rope as I have ever read. It is an 82-page illustrated brochure on the design, uses, operation and application of wire rope. You should have a copy in your files. Wickwire Spencer did as good a job on this as did the American Cable Company on their Wire Rope User's Handbook.

¶ The other day a Minnesota Highway Department patrolman arrested the driver of a suspicious looking truck in Moorhead. He examined the machine and his search revealed the truck to be a perfect example of how a truck should not be. The machine had:

No headlights
Illegal brakes
No rear view mirror
No windshield wiper
No clearance lamps
No horn
No muffler

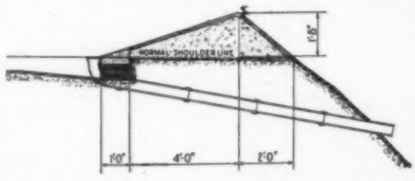
The driver had:

No driver's license on his person
The pleasure of paying a fine

The Highway Department quotes this instance as a warning to all truck drivers to have everything the truck in question had not—and everything else the law requires.

• •

¶ Accompanying is a line drawing of a type of highway guard I found



an engineer was promoting. It eliminates the guard rail. What do you think of the idea?

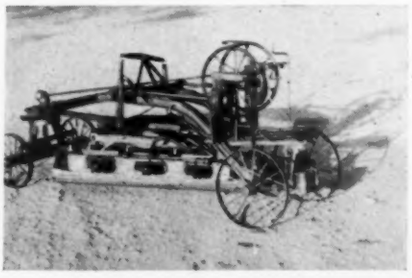
• •

¶ The story is told of a Frenchman, one of the delegations visiting this country to inspect our road work, who returned to France and told his engineering society about our fine roads and how they were named after people like, the Lincoln Highway, Roosevelt Road, Gov. Nice Highway, etc. He said, "There was one Frenchman over there, apparently, and he built the damdest roads. His name was Detour."

¶ The suggestion has been made that a Road Show Hikers' Club be organized. Not a bad idea—Conducted Road Show tour—Over here, ladees and gemmun, we have—. Members would be requested to bring their own chairs, seat canes, stilts earphones and gas masks.

• •

¶ Mr. G. Frank Bullard, Road Superintendent, Hillsboro County, Florida, invented a hot blade grader, shown in an accompanying picture, and has personally supervised road-



mixed tar-sand construction with 2,000,000 gallons of tar during the past three years. He claims many advantages for the unit in bituminous road-mix construction.

• •

¶ Chas. Weaver, a contractor on a Mississippi road job sent a negro to the river for a bucket of drinking water. The man was in the act of reaching toward a deep pool beside an old log, when to his horror, the end of the log opened wide, displaying four glistening rows of teeth. With a shriek he sprang back and tore up the hill to the office. "Boss," he yelled, "dar's the biggess 'gaiter ever was, down in dat ribber. Ah cain't get no wattah."

The white man was soothing. Now Sam," he said, "you don't need to get so excited over a lousy old 'gaitor. Don't you know that 'gaitor was just as scared of you as you were of him?"

"If dat's so, boss," replied Sam, "dar aint no use me going back, cause dat wattah wont be fit ter drink."

¶ A. Puddle Jumper's car jumping puddles on Ohio State Highway No. 151 east of Hopedale, Ohio.

• •

¶ A highway contractor, Moe, was talking with his friend, an equipment salesman, Ike, recently at a letting in which Moe was the successful bidder.

Ike: Well, Moe, it's certainly a grand feeling I experience when I see you, my old friend, land that job. I've taken on the Big Mule tractor line, lately, and figured you might now be in the market for a tractor.

Moe: You figured right, Ike. I am.

Ike: You know how good the Big Mule is. I don't need to sell you on that. Since we've been friends so long, Moe, I'm not going to ask you $3,000 for that tractor. I'm not going to ask you $2,000 for it. But because of our old friendship I'm only going to ask you $1,500 for that tractor.

Moe: Ain't friendship grand, Ike. I've known you a long time, Ike, so I'm not going to give you $1,500 for that tractor. I'm not even going to give you $1,000 for it. But since we've been such good friends I'll give you $900 for it.

Ike: Shake. It's a deal. That's the way I like to do business—No chiselin'.

• •

¶ My idea of a good project: "Fosters Relocation" on U. S. 22 and Ohio 3 about 25 miles north of Cincinnati. Eliminates a bad curve, a railroad crossing, and a narrow, weak

bridge over the Little Miami River. The new bridge crosses the river and railroad 82 ft. above the river bed. Good work, Ohio.

• •

¶ Kid Boyd, sometime Galion Iron Works eastern manager, is considering going into training for the next convention.

¶ I suggest the committee on arrangements for the next meeting of the Association of State Highway Officials of the North Atlantic States take a tip from the committee on arrangements for the dinner dance of the last Asphalt Institute meeting. They'll then make the dancing more enjoyable for all.

• •

¶ Convention pests—Young localites crashing parties.

• •

¶ Speaking of effective drainage, the accompanying picture shows eight inch plugged drain tile replaced by

effective 15 inch corrugated culvert for farm entrance off Ohio Route 36, west of Cadiz.

• •

¶ Bridge over a canal alongside of Ohio State highway number 36 just north of Coshocton, Ohio. It still

serves local traffic. Note the stone abutment.

• •

¶ Squire Fitch, County Engineer, Chautauqua County, N. Y., was presenting a paper at the Atlantic City convention of A. of S. H. O. of N. A. S. when he stopped talking to take a drink of water. It was the second day of the convention. As he reached for the glass he remarked, "Must be the salt air." I wonder.

• •

¶ One State highway department has successfully proven, if a favorable court decision is any criterion, that a State highway system is not an asset to the State. Beat that!

Shown herewith is another picture taken on Ohio State highway No. 151 a few miles west of Wellsburg, Pa.

• •

¶ It has been suggested that we import the Ibis bird from the banks of the Nile to do our road stabilization work instead of using machinery. The Ibis, so the story goes, eats mud and in due course of time leaves bricks behind.

• •

¶ Sign on U. S. 25 between Detroit and Toledo: "Unlawful to Cross Center Line." Ah, yes, and might we add, "Suicidal."

Saw the following sign at a cabin camp on a lake along one of Michigan's highways: "Tourists and Nightcrawlers." Wonder—could they mean "salesmen"?

• •

¶ I see no sense in a driver barging into a possible accident condition. By using his eyes, ears and brain he can keep out of accidents. Of course there is a broad assumption in these statements, I realize, but the suggestion is worth making anyway. ALL MOTOR CAR ACCIDENTS ARE AVOIDABLE.

• •

¶ Finishing a surface treatment with a broom drag on a feeder road in Ohio will eventually produce a

very smooth riding surface. This job was certainly easy to travel, and enjoyable.

• •

¶ A welcome sight in the General Grant National Park in California was a tractor and grader outfit widening the forest road preparatory to placing a bituminous surface treatment. Special crawlers were built into the tractor.

Good and safe roads increase highway transportation which provides jobs for one out of every ten gainfully employed in the United States.

ROAD BUILDERS'

MARCH, 1938 AMERICAN ROAD BUILDERS'

HIGHWAY CONTRACTORS OF

Down the Road

By CHARLES M. UPHAM
Engineer-Director,
American Road Builders' Association, Washington, D. C.

OBSOLETE ROADS DOOMED

A recent edition of one of the newsreels pictured the destruction of hundreds of obsolete automobiles as the very latest in highway safety campaigns. These cars had been declared unsafe for further use. They were gathered together and liberally doused with kerosene. Set afire, they went up in a gigantic blaze. Those present at this exhibition congratulated themselves on having rid the roads of these defective motor vehicles which had added to the dangers of driving.

Getting rid of old and unsafe cars, however, does away with only a part of the dangers of driving. It is too bad that the obsolete and unsafe roads of the nation cannot also be gathered into one spot and destroyed. The most modern automobile, equipped with all the latest safety features, will continue to be involved in serious traffic accidents unless safety is built into our highways. Defective cars may be blamed for some of the 40,000 traffic-accident deaths during 1937, but at least 50 per cent of them could have been avoided by the construction of up-to-date, safe roads. The overcrowded, worn-out road is the most relentless of all death-traps.

It is gratifying to note that Congress is aware of this need for more and safer highways, as evidenced by the recent introduction of several bills to provide for the construction of super-highways across the continent. President Roosevelt has also expressed interest in and approval of these plans. We must keep in mind, however, that while the country's entire highway system must eventually be remodeled, such a program would not be economically possible at the present time. An exhaustive survey should, therefore, be made to determine if and where the building of super-highways would at present be most valuable and between what points the possibilities for accident-reduction and the alleviation of traffic congestion would most economically justify their construction and maintenance.

The steadily mounting highway-accident death rate is gradually awakening the public and their lawmakers to the need for action. It is especially important now that a careful study be made of our highway needs in order that this action and the funds appropriated for this purpose may be directed into the channels where they will be most effective and productive of the best results.

The American Road Builders' Association last month added another strong and active group to its highway contractor membership which includes many affiliated organizations throughout the country. The Mississippi Highway Contractors' Association, Inc., voted to join forces with the A.R.B.A. in order that it might aid more forcefully in the campaign to build safety into the nation's highways and work more effectively for the continuance of an adequate highway program.

Charles M. Upham, engineer-director, and Colonel Willard T. Chevalier, president of the A.R.B.A., were speakers at the legislative banquet of the new affiliate in Jackson. Mr. Upham, Colonel Chevalier and other guests of the Mississippi Highway Contractors' Association, including H. K. Bishop, chief, division of construction, U. S. Bureau of Public Roads; Charles D. Snead, district engineer, Montgomery, Ala.; F. A. Davis, senior highway engineer, Mississippi; E. D. Kenna, director, Mississippi highway department; R. A. Harris, chief engineer, Mississippi State Highway Department, and J. D. Lewis, district engineer, southern district, Mississippi, were conducted on a tour of inspection down Highway 49 to Hattiesburg. On this trip they visited projects now under construction by various members of the contractors' association.

Officers of the Mississippi organization, which has a membership of seventy, include M. G. G. Cobb of Cobb Bros. Construction Co., Meridian, president; S. B. Ziegler of Ziegler Construction Co., Nashville, Tenn., vice-president; Ellis Hoffpauir of Dunn Construction Co., Montgomery, Ala., and Jackson, Miss., secretary-treasurer, and R. N. Kinnaird, Jackson, executive secretary. The directors, in addition to these officers, are Frank A. Barber, of Barber Bros. Construction Co., Baton Rouge, La.; John M. Harbert of Harbert-Cargile Construction Co., Birmingham, Ala.; C. F. Shuptrine of Shuptrine Construction Co., Natchez, Miss.; Wade E. Moore of Forcum-James Construction Co., Dyersburg, Tenn., and Alex J. White of West Construction Co.

REVIEW

In 1910 the tire cost for a passenger car amounted to about a penny a mile; in 1925 about an eighth of a cent; today about one-twenty-fifth of a cent. Tires are better — and so are the roads they run on.

ASSOCIATION—WASHINGTON MARCH, 1938

MISSISSIPPI JOIN A. R. B. A.

SUPER-HIGHWAYS

AN INTERVIEW WITH

SENATOR ROBERT J. BULKLEY OF OHIO

Sponsor of S. 3428, a Bill to Provide for a Transcontinental System of Super-Highways

The American motorist has for many years been the victim of diversion of highway revenues to non-highway purposes. A bill recently introduced in the United States Senate proposes a new kind of diversion—the diversion of public money which would otherwise be used for temporary relief of unemployment into channels where it will not only relieve this unemployment but will at the same time be of benefit to everyone interested in the American highway system.

Senator Robert J. Bulkley of Ohio, sponsor of this bill which would provide for a transcontinental system of super-highways, explained that "I regard this program not as a plan to spend a lot of money which would not otherwise be spent, but rather as a plan for diverting these sums which would have to be spent for ordinary human needs into self-liquidating projects. Everyone agrees that a certain amount of money must be devoted to relief purposes. No one must be allowed to starve, and work is certainly better than a dole. Use of this money for the construction of roads means that unemployment will be reduced, and the public will at the same time receive complete value for the funds expended."

The Bulkley measure further provides that tolls shall be charged for the use of these super-highways. As all proceeds from such charges will go for the construction, maintenance, administration and policing of these highways, and for retiring the bonds issued to build the highways, it is hoped that the cost of these projects will be self-liquidating.

"These tolls," Senator Bulkley pointed out, "will not be in the nature of a tax. They will be in the nature of payment for value received. This value will first of all consist of the increased safety and feeling of security with which a man and his family will be able to travel on these roads. There will also be a saving in gas and oil since the distances between points will be reduced and because the number of times that it is necessary to start and stop will be materially decreased. The reduced wear and tear on his car and his tires which will result from the improvement of the highways is also an important consideration."

The senator cited the German system of super-highways as an example of the remarkable results in cutting down the number of accidents which can result from the carefully planned and scientific design of roads. He declared that all kinds of accidents would be greatly reduced in number and that certain types of accidents would be entirely eliminated by the construction of super-highways.

"For example," he pointed out, "since my plan provides for the elimination of all cross-roads, this particular type of collision which is responsible for so many fatalities today will be completely done away with. Every other safety feature built *into* these highways will likewise mean protection from certain kinds of accidents."

The saving of lives and property is not the only benefit which will flow from the carrying out of this plan, according to Senator Bulkley.

"A general increase in employment will, of course, follow the employment of men to build roads. Those industries which produce materials or equipment used in road building will benefit directly. But every other industry will also benefit through the increased employment and consequent increase in spending power."

Senator Bulkley also emphasized the importance of a super-highway system for national defense. He explained that it is needed to facilitate the transportation of men and materials, and would also be particularly important if it became necessary to evacuate certain areas.

"This bill to provide for super-highways can be supported with equal consistency by those who favor the President's proposal to economize by curtailing road appropriations and by those who oppose it," Senator Bulkley explained.

"This bill," he declared, is not intended to serve as a substitute for regular federal aid to states. It merely provides for super-highways to be built by a government corporation which would be self-liquidating. It would not, therefore, result in any unbalancing of the national budget."

In the Days Before Gas. The Grandpap of the Large Tractor-Drawn Scraper Grading New Location in New York State.

THE MANAGEMENT OF HIGHWAY GRADING

The Sixth of a Series of Articles Dealing With Its Economic Aspects

By J. L. HARRISON

Senior Highway Engineer,
U. S. Bureau Public Roads, Washington, D. C.

THE most recent development of major importance in the highway grading field is the large tractor-drawn scraper—grandson of the slip scraper, long the most widely used tool in the grading field! The large scraper was brought out in the West several years ago, where it was developed into a practical, efficient tool. During the past three or four years its use has spread eastward at a rapid rate until, today, it is known and considerably used in all parts of the country. It is available in various sizes of which the 12 cu. yd. unit appears to be the one most generally employed in the highway field.

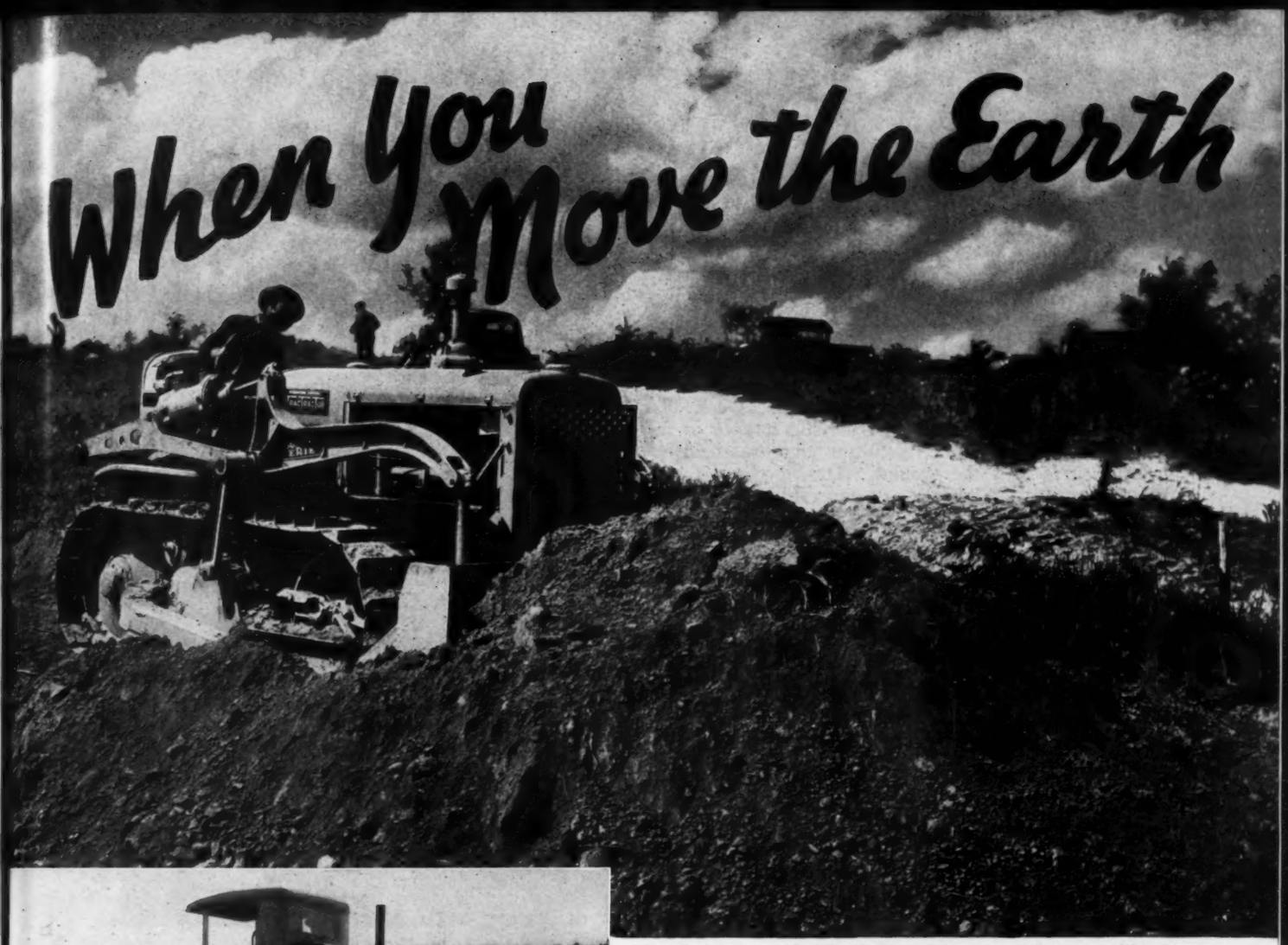
The ordinary practice is to use one scraper with the tractor but, except on short hauls, two can often be advantageously handled when ground conditions are satisfactory. The units are rugged, well built and highly dependable, carrying anything they can dig, dumping it easily and quickly as they run and, as they require only one operator, who drives the tractor and handles the scraper, the cost of operation is strikingly low. Of equal importance from the practical standpoint, each unit is in itself a complete grading outfit capable, on moderate lengths of haul, of laying down about as much dirt in a day as is usually turned out by a 1¼-yd. shovel —in fact, more than it produces under other than reasonably good management—and can do this with a minimum of supervision.

Though these scrapers are relatively a new thing, it already is apparent that they are destined to alter grading practices more radically than they have been altered since the elevating grader was first introduced in the prairie regions as a device for quickly and efficiently loading wagons. This being the case, rather a detailed statement of the reasons these scrapers are so effective, of how to use them and of what they are capable of doing may be of interest both to those who have used them and to those who are considering them as equipment units.

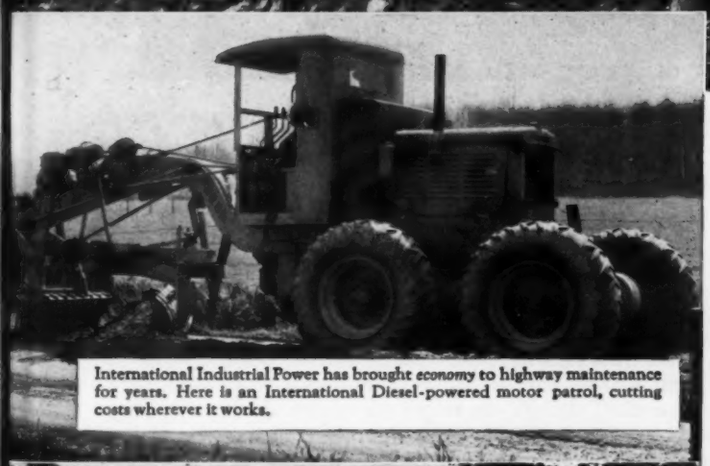
Tractor-Drawn Scraper Efficient Hook-Up

Tractor-drawn scrapers are, as their name implies, scrapers made so large that their size is in relatively good balance with the pulling power of the tractor used to haul them. The tractor is a low speed unit. Low speed is of advantage in the highway grading field for it is quite difficult to maintain the ground over which hauling must be done in such condition that high speeds can be consistently used. There is, of course, no such thing as an exact balance as between a power unit such as a modern tractor, and the load it is hauling but the large scraper does offer about as close a balance between the demand for power and the power that is available as engineers have so far been able to work out. In short the hook-up to start with is fundamentally about as efficient as it is possible to make it, the highly varying conditions under which such units must work

When You Move the Earth



This is the International T-40 TracTracTor bulldozing dirt. An International Diesel engine is also available for this sturdy crawler. International Industrial Tractors are readily adapted to a wide variety of in-built equipment.



International Industrial Power has brought *economy* to highway maintenance for years. Here is an International Diesel-powered motor patrol, cutting costs wherever it works.

An International T-20 Trac-TracTor pulling a sheep's-foot roller, and in the background a larger International with bulldozer.

● More dirt-moving is being turned over to International TracTracTors all the time because they have the stamina this rough-and-tumble job demands. In no other service does TracTracTor design and International Harvester *quality* construction show to better advantage. Year-after-year performance on the job has proved the value of the many features International Harvester has brought to the crawler-tractor field.

International TracTracTors convert an *exceptionally large percentage* of their engine power into useful work. All vital parts are *completely protected* against entrance of abrasives and water. No matter how thick or penetrating the dust, the oil seals in TracTracTors keep it out. Steering clutches, operating on high-speed shafts, permit *"finger-tip" control* that gives *extra quick* response and *extra ease* of operation. Steering clutches and brakes are *so readily accessible* that they can be inspected, adjusted, or replaced in a minimum of time.

Such things as these are reflected in the cost sheets—they make possible the *economy of operation and maintenance* for which TracTracTors are famous. These crawler tractors are available in five different models, for gasoline and Diesel operation. There also are five wheel tractors in the International line, and power units ranging up to 110 max. h. p. Ask the nearby International dealer or Company-owned branch for complete details.

INTERNATIONAL HARVESTER COMPANY

180 North Michigan Avenue (*Incorporated*) Chicago, Illinois

INTERNATIONAL Industrial Power

being considered. It may also be remarked that, production capacity being considered, the investment the ownership of equipment of this sort involves is low. This does not mean that these outfits are cheap, for they are not. However, as the cost of a tractor and scraper is a good deal less than the cost of a shovel of equal ordinary output capacity and the hauling equipment that must be used with it, these outfits generate relatively low unit charges for depreciation. Relatively speaking, as Diesel power is all but uniformly used, the cost of fuel and oil is even lower, as is the cost of the labor their use involves.

The scraper is a scraper in fact—that is just as the slip scraper and the wheel scraper were scrapers. To take on a load, the mules pulled the slip scraper or the wheel scraper along while its cutting edge was held below the surface of the ground. This forced the load into the scraper. When the proper load had been taken on, the position of the scraper was altered so that it took on no more material, after which it was hauled to the dump where the load was dropped. The modern large scrapers are, in principal, merely a revised and enlarged edition of the old fashioned scrapers which—more particularly the wheel scraper—they definitely resemble. The mules have given place to the tractor. There are a few new levers. Still, by and large, they are the same old tool grown to magnificent proportions.

Available Power and Probable Load Balanced

Here again one sees the careful engineering balance between available power and probable load which makes these units so effective. It took a snatch team—often 4 up—to load a wheel scraper that a two mule team could take to the dump. It takes only the shifting of a lever to give a tractor the added draw-bar pull hitching on the snatch team produced in front of the wheel scraper. In low gear the pull a large tractor can exert is so enormous that large scrapers are fully loaded with comparative ease. For hauling, the shifting of a lever makes the power available for higher speed instead of draw-bar pull. In short, both in digging and in hauling there is a reasonable balance between the tractor and its load—a balance which does not waste investment in power plant but which does leave enough spare power to meet unusual and emergency requirements.

In what has been said above, some emphasis has been laid on the balance scraper-tractor outfits maintain between power plant and load. To some this emphasis may seem to be too great. To those who feel that this is the case it is suggested that the power plants used on a shovel or on an elevating grader job in digging and hauling 100 cu. yd. of dirt an hour be compared with the power plants in use on a scraper-tractor job on which 100 cu. yd. an hour are being moved the same distance. Almost invariably it will be found that several times as much power is available on the shovel or the elevating grader job. True enough, much of this difference in the amount of power that is available can be utilized, when conditions permit, in moving heavy loads at higher speed. If it could be so used with any reasonable degree of consistency the relative importance of the large tractor-drawn scraper as a grading tool would be considerably altered. The fact of the matter is that conditions do not, in most regions and on most jobs, permit of its being utilized in this way.

Diversity of Material Handled by Large Scraper

There is another similarity between the modern large scrapers and the old fashioned small scrapers—their natural field is good common. However, the modern large scraper is not limited to handling material of this character. It will dig good common without plowing. It will also dig material such as wet clay that is by no means "good" common though in the very nature of the case wet sticky clay cannot be handled as easily as really good common. Shales, hard pan, soft rock, lightly cemented gravel—any material that can be broken up by a tractor-drawn plow so that it can be loaded—can be taken on and carried. Even well shot ledge rock can be handled, though, as might be expected, this is pretty hard on the scrapers. However, contractors who find a little flat lying rock in the bottom of a cut, an occasional small rock dyke, a few boulders or other minor amounts of rock have found that if such outcroppings are so well shot that they can be picked up by the scraper they are handled readily enough. Obviously, the danger in work of this sort is that the rock will not all be broken off below the floor of the cut with the result that the cutting edge of the scraper will catch on high spots that remain and wrench the machine badly. Contractors with whom the writer has talked say that the danger of seriously injuring the scraper is not great but that repairs to the scrapers and the tractors mount up when work of this kind is being handled. It would appear, however, that even after allowing for the increased cost of repairs work of this sort involves, it is now quite generally considered better practice to use the scrapers in taking out minor amounts of rock than to resort to other methods. The point here is that the scrapers will handle this work when called on to do so!

Some Tough Going in Grading Cut on Farollone City-Rockaway Beach, Calif., Highway.

FOR COMMUNITIES THAT

Can Afford To Be Thrifty

● The few extra dollars that it costs to build a brick pavement is the thriftiest expenditure a community can make. Brick's huge saving on upkeep soon makes it the cheapest. ¶ These savings in upkeep expense recur annually during the life of the pavement which frequently runs 40 years or more. ¶ The reasons: No other pavement can excel brick in resistance to traffic damage—*no other pavement can compare* with brick in resistance to weather damage. ¶ National Paving Brick Association, National Press Building, Washington, D. C.

Thrifty Annapolis, Md., paved King George Street with brick 40 years ago. Today it is still giving good service.

BRICK

FOR NEW CONSTRUCTION OR RESURFACE JOBS

Five Yard Scrapers on Oregon Coast Highway.

They are, then, relatively versatile and so can be depended on to handle all of the digging and hauling on jobs on which all but a minor fraction of the excavation is properly classed as common and at least much of it on jobs where a considerable fraction of the work is classed as solid rock.

It has been remarked that these large scrapers reduce the management problem to a minimum of simplicity. It would be difficult to lay too much emphasis on this fact. As each unit digs its own dirt, loads it, hauls it and deposits it on the dump, no problem is involved in keeping the outfit in balance. Hour after hour and day after day the scraper moves back and forth in an elongated loop of whatever length job conditions require, digging where required and dumping where required with a steady smoothness of operation which, given a dependable operator, needs little supervision and offers little opportunity for anything other than a satisfactory rate of production.

Where Savings Can Be Made

Still, as simple as the operation of these outfits is, from a practical standpoint there are points of interest even in this simplicity and points at which savings can be made.

As just remarked, travel is in an elongated loop. This loop involves (1) digging which should usually be done while traveling toward the dump, (2) hauling to the dump, (3) dumping, (4) turning on the dump, (5) returning, and (6) turning in the cut. In good common, the ordinary digging run is in the neighborhood of 100 ft. The dumping run is about the same if thin layers are being laid down. If thicker layers are used the dumping run is, of course, correspondingly shortened. In good common, then, the average loop traveled by the grader is about 100 ft. greater than the average distance from the center of mass of the cut to the center of mass of the fill, plus whatever distances at each end of the loop are required for turning around. In heavy clays or where, for any other reason, digging is difficult the loading run is likely to be somewhat longer. Digging is, of course, done in one of the lower gears.

In the highway field most of the hauling is done on a downhill pull so, as a rule, it is done in one of the higher gears. Not infrequently, however, the haul is from a borrow pit and when it is, an uphill haul usually is involved. If the grade is steep, one of the intermediate gears must be used.

Theoretically, when the tractor is hauling a single scraper it usually can, on highway work, haul its loads (downhill) and return empty (uphill) in high gear—that is at about 5 miles an hour. However, road conditions seldom are such as to encourage speeds as high as this with the result that most of the work is likely to be done in fifth or even in fourth gear. If the latter gear is used on a 900 ft. average haul, that is on an average loop that measures 1,000 ft. from the point at which the scraper begins to dig to the point at which the last of the load is dropped, some 50 yd. an hour should be handled by a 12 yd. scraper. If sixth gear is used, about 75 yd. an hour can be handled. These figures are based on standard tractor speeds, on 8 cu. yd. net per load and an average of two minutes lost per load in turning, in digging in low gear and in dumping which are standard allowances. From this one illustration it is clear that there is a good deal of a premium on working at as high speed as possible. On the other hand it cannot be assumed that all of the apparent advantage of high speed can be taken as profit. When motors are driven at top speed, inevitably their useful life is definitely shortened. An increase of 50 per cent in the yardage an outfit will produce is relatively a large increase. If road conditions are good the wear and tear on the equipment is not likely to be sufficient to affect it. Where road conditions are poor, the result of the use of high speeds is unlikely to prove as profitable. Contractors do not agree as to the best operating speed. The writer is inclined to the opinion that under conditions such as usually prevail on highway work operation at a moderate speed is preferable to "high balling" the scrapers.

Calculating Average Time per Load

When the scrapers are operating on a simple loop the average time per load that will be required in placing material from a given cut in a given fill can be obtained with a reasonable degree of accuracy as follows:

To the average haul distance from the cut to the fill add 100 ft. Multiply the sum by 2. This gives the average distance the scraper must travel in taking out a load and returning for the next while constructing that particular fill. Divide this figure by 88 times the travel speed in miles per hour for the gear in which the tractor is being operated (3.2 for fourth gear, 3.8 for fifth gear or whatever other speed may be involved). The result will be the number of minutes used per load

Dressing Up Side Borrow Ditch on a Mississippi Highway.

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A 12-Yd. Scraper Working in a Cut.

in traveling. To this add 2 minutes for digging in low gear, turning, etc. The sum is the average trip time. To illustrate, the average haul from the cut to the fill between balance point 7 and balance point 8 is 1100 ft. The average tractor loop distance will, then, be 1200 ft. and the average travel distance 2400 ft. If the tractor is being operated in fourth gear, we then have a travel time of 2400 divided by (88 x 3.2) that is 2400 divided by 281.6 or for easy calculation 2400 divided by 280 or 8.5 minutes, to which must be added 2 minutes for loading, turning, etc., making an average round trip time of 10.5 minutes or 45 loads per 8-hour day which, if 12 yd. units are in use, is an average production of 360 cu. yd. per unit. Probable production on each fill on the job can be readily calculated in this way.

In highway work it seldom is necessary, except in cutting, to work at a lower speed than that used above if the tractor is hauling only one scraper. On the other hand, as previously noted, higher working speeds yield larger outputs. Thus, for the conditions noted above a speed of 3.8 miles an hour lowers the average round trip time to slightly over 9.1 minutes which increases output to 52 loads per 8-hour day. If the scrapers are "high balled" production is further increased to 67 loads per 8-hour day. The speed at which these units should be operated will depend on ground conditions and on the contractor's opinion concerning the advantages—or the lack of them—that high operating speeds present.

Some Points on Larger Scraper Operation

In the practical operation of large scrapers it is, of course, axiomatic that the high side of the cut is taken out first and that the low side of the fill is laid down first. The objective is to reduce the cut to a level floor and the fill to a level dump. The work of trimming cuts is reduced by using a little care in offsetting at the slope walls of the cuts as the cutting progresses. A first class operator can offset so accurately that very little work is required on the cut slopes. If the cut slope is 1½ to 1 the offset should be 1½ times the depth to which the scraper is set to cut. If the side slope is 2 to 1, the offset should be twice the depth to which the scraper is set to cut.

It has been remarked above that normally these scrapers operate in a loop and that, as a rule this loop is about 100 ft. longer than the average distance material is moved. This 100 additional feet of loop length involves an extra travel distance of about 200 ft. per trip. Turning twice to make the loop with such loss of time as is involved in digging in low gear and in dumping amounts to about 2 minutes. These two items amount to a little less than 3 minutes per trip and account for the practice, often followed where successive cuts are close together, of working two cuts at the same time. To illustrate, fill 7 is to be made of material taken from cut M, which is east of it, and from cut N, which is west of it. The scraper, having taken its load in cut M dumps it on the fill and goes on to cut N. There it turns, picks up a load, and in returning dumps it on the fill and goes on to cut M. As this practice results in only one turn per load taken out and also reduces the extra travel to 100 ft. per load, it has the effect of reducing the time consumed per load carried about 1 minute. This is an important saving on short haul work and is apt to be well worth considering even on long haul work. Thus, if hauling is being done in fifth gear and the average distance the dirt is being moved is 550 ft. (travel distance 1300 ft.), ten loads an hour should be taken out or 100 loads in a 10-hour day. Under these conditions a saving of 1 minute per load would increase production to 12 loads per hour. This is a saving in time—an increase in production—quite large enough to be of interest.

Even on a haul of moderate length the saving of 1 minute per load is well worth while. Thus, if dirt is being moved 1600 ft. (average travel distance 3400 ft.) and fifth gear is being used, the round trip time should be about 12 minutes—50 loads per 10-hour day. Here a saving of 1 minute per load means an increase of at least 4 loads per day—some 8 per cent in production.

Production Increased by Working Two Cuts at Once

Other illustrations would serve merely to add emphasis to the fact that, when the work can be handled in this way, the practice of working two cuts at once can produce a real increase in production that is large enough to be of definite interest. It should be remarked, however, that this practice is not to be followed blindly. Its value rests on the elimination of one turn per trip and on the elimination of a certain amount of travel distance. This value is lost if these savings are eliminated as a result of other factors this practice may involve. Thus if, as often happens, the distribution of the material is such that a longer average travel distance is involved in taking out material in this way than in taking it out on the simple loop basis, the advantage of following this practice may be lost. If this longer travel distance exceeds about 300 ft., all advantage is lost except as the plan can be applied in dumping material that lies close to the middle of the fill. Figure 1 will illustrate.

In Fig. 1 the average distance the dirt lying between

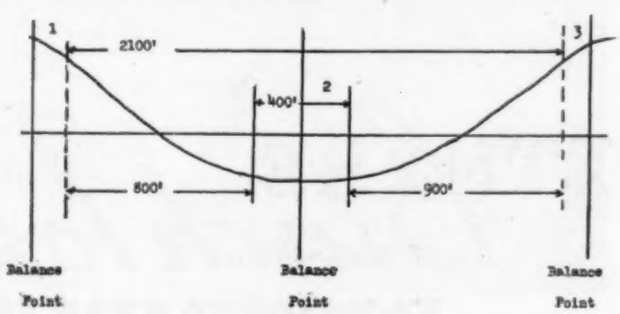

Fig. 1

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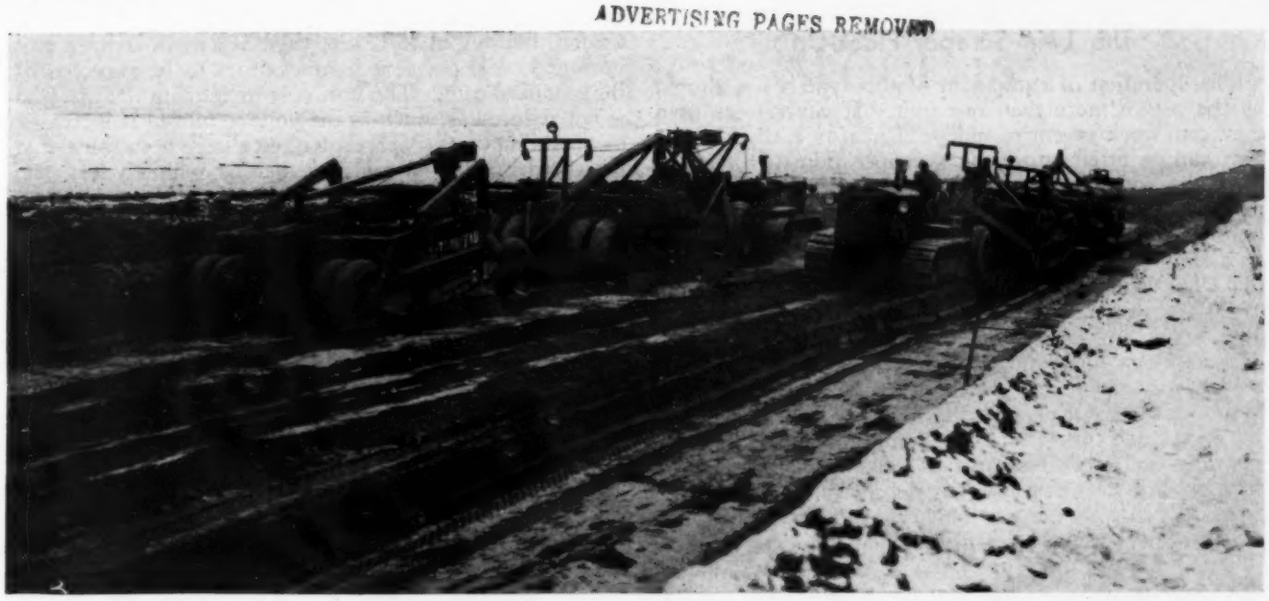

Tandem Operation on a Western Highway.

balance points 1 and 2 must be moved is 800 ft., yielding a simple average loop length applicable on the material lying between balance points 2 and 3 is 1000 ft. Assuming equal quantities of material between each of these pairs of balance points the average loop length is 950 ft. and the average travel distance over which the scrapers would move in making the fill would be about 1900 ft. plus the distance used in turning. This distance is not great but the time lost in turning and digging and in dumping—about 1 minute per turn—is roughly equivalent to that used in running 300 ft. The simple loop then, in this case involves running 1900 ft. plus turning time equivalent to 600 ft. or a total of 2500 ft.

The Two-Load Loop

If the scrapers are run through, loading first from one cut and then from the other, the average loop length is 2200 ft. (2100 + 100), which yields a travel distance of 2200 ft. for each load hauled. As only one turn per load is involved, the turning time equivalent is only about 300 ft. which, again is a total of 2500 ft. In this case, then, no real advantage could be had from operating these two cuts on one loop. The distance, shown in Fig. 1 as 400 ft., is variable from fill to fill. When this distance reaches about 400 ft. and for greater distances the run through usually is not of advantage.

The above observations are based on using the two load (one from each cut) loop in making the whole of the fill. However, if instead of doing this the short haul at each end of both fills is handled on a simple (single load) loop basis and the material near the center of the fill is handled on the two load loop basis, it will usually be found that the economies of the two load loop can be obtained over at least a major fraction of the work. Some care—or perhaps it would be preferable to say a little figuring—is required in order to make sure that the equipment is being used to the best advantage. As will be seen from the above, this figuring is quite simple. The better utilization of the equipment that results from this figuring, amply repays the time it requires.

Besides applying it in making one fill from two cuts, the two load loop can be and indeed often is applied in taking the material from a cut to the fills that lie at either end of it. This application of the two load loop looks simple enough, and would be equally simple in practice if balance points always came at the center of the cut or even if an equal amount of material had to be moved in each direction. Unfortunately for the dirt mover, design never is as simple as this! When working in short cuts the fact that 75 per cent of the material goes one way and 25 per cent the other is no great drawback to taking out half the material on a two load loop basis and in ordinary rolling country this can, as a rule, be done to advantage. When this is done the first load is hauled, we can assume, to the fill at the west end of the cut where it is dumped. The turn is then made and on the return trip a load is picked up in the cut and taken to the fill west of the cut, etc. In short the loads are taken at about the middle of the loop rather than at its two ends but this is a detail which has no effect on the savings it was pointed out above lie in the two load loop as compared with the simple or single load loop.

When a cut is long and the balance point is some distance from the center of it the use of a two load loop loses its advantage in much the same way that was described above as frequently occurring when the two load loop is applied in taking material out of two cuts simultaneously. In short extra haul is generated in getting material into one or into both of the fills. Again, if this extra haul amounts to more than some 400 ft. per load carried the advantage of the two load loop is likely to be lost. In practice, while there are, of course, many exceptions, the fact that extra haul is involved in the use of the two load loop in this manner is pretty apt to be related to the fact that the material to be taken out of the cut does not move in equal amounts to the fills at its two ends. When this is the case, and the cut is fairly long and not too deep, it may prove economical to take out enough of the material going to the larger fill both to shorten the cut and to throw the remaining yardage into balance as between the two fills into which it must be dumped, after which the two load loop can be applied to advantage in taking out the remainder of the cut.

The Twin Scraper Hook-Up

The operation of equipment of this type is not altered by the use of more than one unit. If several are used they can work in entire independence of each other or they can be fitted into a plan of operation the better to meet the conditions at the moment prevailing. Thus, under actual working conditions, if there are several units at work on a fill one can be assigned to short haul on a simple loop out of each of the two cuts from which the fill is being built while the others handle long haul material toward the middle of the fill on a two load loop basis. As each is a unit complete in itself, compact and easily manipulated, they do not get into each other's way, do not obstruct each other's progress and in no other respect interfere with each other's operations. In fleets their operation can therefore be so arranged that any ordinary situation that arises in handling highway grading economically and expeditiously can readily be met. In short, their manner of operation is such that they lend themselves about equally to operation as isolated units and to operation in fleets, operation in fleets on the whole being perhaps a little more advantageous where the amount of work is sufficiently large to justify the use of several units.

On highway work it is customary to attach only one scraper to a tractor. This is due to two facts—first that on highway work average hauls from the cuts to the fills usually are from short to only moderately long and, second, to the fact that the cuts vary a good deal in length, some being short, some of moderate length and some long. As a rule gradients are moderate with the loaded haul downhill.

The fact that gradients usually are moderate and that the loaded haul usually is downhill tends to favor the twin scraper hook-up—two scrapers to the tractor. The tractor has ample power with which to handle digging and hauling on this basis, other physical conditions being reasonably favorable.

Therefore, as the tractor expense, labor, operation cost, etc., is reduced as the yardage moved per day is increased, there is a good deal of incentive for operation on this basis if output can be increased more than cost is increased. That this result can be obtained on consistently long hauls from large digging areas is not open to question. But in the highway construction field the contractor, as noted above, usually faces the fact that much of the dirt he is handling is moved only a short distance, that the distance it must be moved varies a good deal from cut to cut and that the length of the cut varies from short to long with no regularity in their arrangement or in their size. The importance of these matters in a determination of whether and to what extent the twin scraper hook-up can be used to advantage in the highwey field arises from two facts. The first of these is that the cutting run and, in general, the dumping run are doubled in length when twin scrapers are used. This being the case the length of the travel loop is increased a couple of hundred feet or so if this hook-up is employed. Moreover, the constant for extra time used in digging, turning, dumping, etc.—given above as two minutes for the standard tractor single scraper unit—is about doubled. These two factors taken together have the general effect of preventing the twin hook-up from yielding a materially larger yardage or a lower cost per yard handled unless material is being moved some 500 ft. or more. When material must be moved further than this, the advantage of the twin scraper hookup increases as the distance the material must be moved increases until at 2,500 ft., as an illustration, the output to be expected of a twin scraper unit is roughly 190 per cent of the output to be expected of the standard unit. The unit cost of moving the material is not reduced as much as the volume moved is increased as operating costs, depreciation, etc., have been somewhat increased. Still as the increase here is definitely less than the increase in output, unit costs are definitely reduced.

But while there is no question that where working conditions are otherwise favorable the use of two scrapers with each tractor reduces unit costs on hauls of over some 500 ft., the fact remains that this hook-up is not attractive on shorter hauls and that ordinarily highway construction requires the movement of a great deal of material over distances that are well within this limit. If this short haul material was located in a few areas or in some particular portion of the project, it would act as less of a deterrent on the use of the twin scraper hook-up. However, the fact is that pretty much every fill involves some short haul material and that while the trend in design is definitely in the direction of heavier fills and longer hauls this trend has not yet had the effect of making long hauls a dominant feature in highway design. This fact, coupled with the closely related fact that many of the cuts are too short to be worked to advantage with a twin scraper hook-up has tended to discourage operation on this basis.

While these facts cannot be seriously questioned it should, perhaps, be remarked that they seem to have been given more weight than they really deserve. True enough, an outfit composed entirely of tractors drawing two scrapers would usually prove disadvantageous even on relatively heavy highway construction. However, it is equally true that on other than light construction there usually is ample opportunity to make use of one and sometimes of more than one operating unit of this sort. Here, as in connection with previous comments on this matter, attention may properly be called to the fact that every unit is an independent producer the efficiency of which is not in any way dependent on what other units are doing. If this fact is accepted as the basis on which tractor-scraper units are to be managed, it follows as a matter of both logical and practical conclusion that long haul from large cuts can be handled to advantage by twin scraper outfits, short haul and work in short cuts being reserved for single scraper units.

It is, of course, perfectly true that operation on this basis will require a little more managerial attention than is required in the use of only single scraper outfits but the better return—lower average production cost—obtainable under this sort of operation justifies this attention.

▼

Jury Appointed to Select Elevated Highway Design

A jury of nationally-known engineers and architects has been appointed to select the prize-winning designs for an elevated highway submitted in the Students' Bridge Design Competition which is held each year by the American Institute of Steel Construction. The jury this year will consist of Frank M. Masters, Consulting Engineer of Harrisburg, Pa.; E. H. Praeger, Chief Engineer, Madigan-Hyland, New York; Aymar Embury II and Randolph Evans, Architects, of New York, and Howard Myers, Editor of *The Architectural Forum*. The jury will meet on April 19 to make the selections from the designs then submitted. Competitors must submit their designs on or before April 9.

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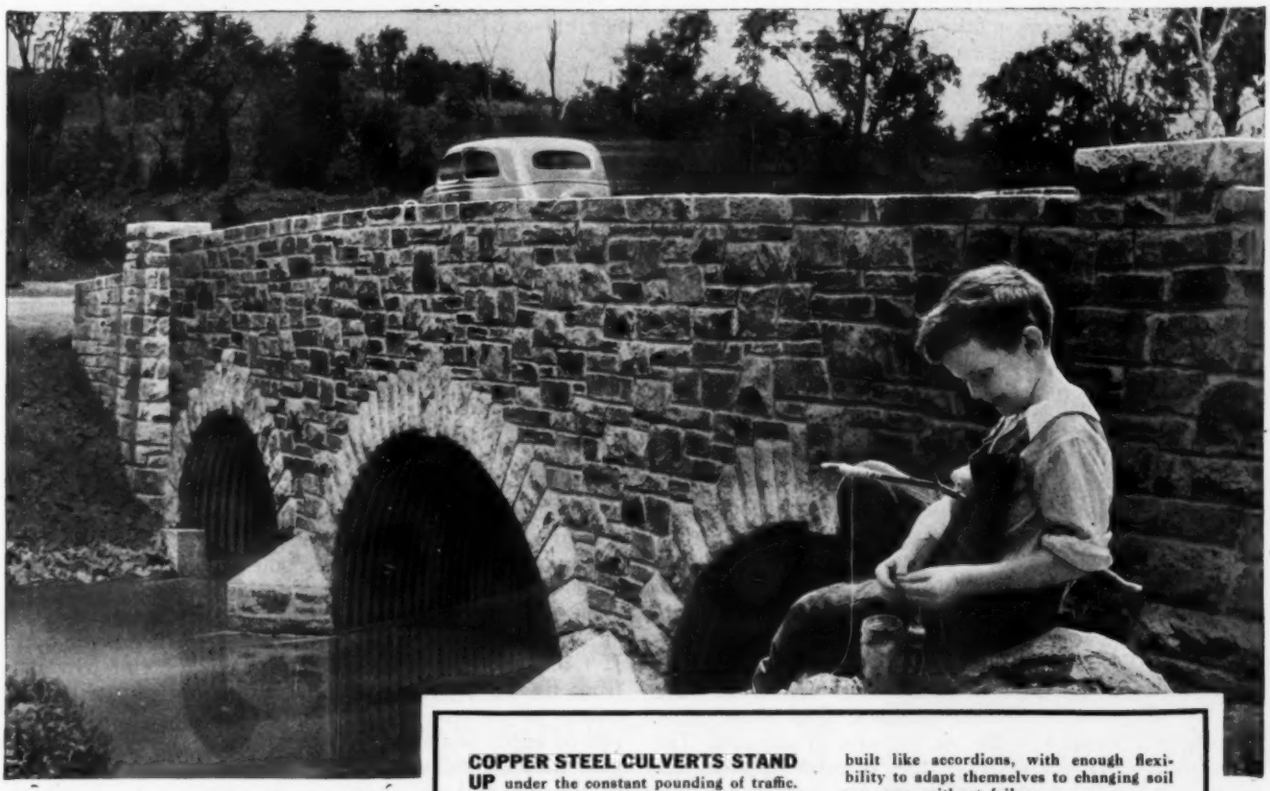

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UNITED STATES STEEL

THE CAUSE OF ICE AGES IN THE TROPICS

By HALBERT P. GILLETTE

ONE of the many puzzling facts disclosed by geological research is latitudinal climatic inversion, such as the former existence of very temperate climate near the poles and very frigid climate in the tropics. It has often been suggested that the inclination of the earth's axis has frequently differed greatly from its present angle; but astronomical physicists have proved that this is impossible. Consequently many fantastic guesses have been made to account for these climatic inversions.

This puzzle, along with several others, ceases to be a puzzle upon adopting an electron theory in place of the solar-heat theory that has dominated meteorology from the beginning, which means for centuries. The electron was discovered only about 40 years ago. Hence the electron theory of weather and climate is engaged in a stern-chase that is rendered exceedingly difficult because scores of authorities can be cited in favor of the alleged all-sufficiency of the solar-heat theory. Moreover, that theory is partly sound, and so well explains seasonal changes in temperature that one is apt to overlook the fact that it throws much less light on the cause of differences in seasonal rainfall in different regions, and has thus far failed satisfactorily to explain either ice-ages or the latitudinal shifting of climatic provinces.

Michael Faraday was perhaps the first to suggest other causes of air currents than heat convection. He believed that the terrestrial magnetic field must cause the magnetic oxygen of the air to move in currents. The late Prof. F. H. Bigelow, of the Weather Bureau, invoked solar magnetism to account for certain air currents and their correlation with changes in magnetic forces. Dr. C. J. Kullmer proved that average storm tracks tend to move in arcs having the magnetic north pole as their approximate center shifting to higher latitudes when sunspots are most numerous. In two great books, Dr. Elsworth Huntington has not only summarized previous evidence in favor of an electron theory of weather, but has given additional evidence based on his own analyses of data. Dr. Benjamine Boss, the astronomer, has recently adopted the electron theory of air currents.

For 12 years the writer has advocated an electron theory of weather cycles and has published additional evidence of its truth. In the present article it will be shown how electron theory can explain the latitudinal shifting of climatic provinces.

Both the earth and the sun constantly emit electrons. Electrons in motion are magnets. Since the interior of the earth is extremely hot, and probably molten, it can not be a magnet unless there are free electrons there in excess of protons; for if the numbers of these negative and positive units of electric charge were equal, their concurrent motions would produce equal and opposite magnetic fields that would nulify one another. The writer infers, therefore, that the earth's internal magnetism must be due to permanent cyclonic whirls in the molten core of the earth. The strongest pair of these cause the magnetic north and south magnetic poles. The next strongest pair cause the secondary foci of which one exists in Russia and the other in Antarctica. There are many minor magnetic foci in the earth.

While the earth's axis cannot greatly change its inclination, the same does not hold true as to its magnetic axis. Its poles not only can, but do shift considerably. The magnetic south pole has moved about 100 miles to the northeast since its discovery. Therefore it is apparently rotating in the same direction that the earth rotates, but very slightly faster. In this respect it behaves like the air in temperate and frigid zones, where it flows eastward. It can be shown by electron theory that electrons escaping from the earth must move spirally, poleward around magnetic axes; and since electrons attract molecules, there must be a rotary motion from west to east imparted to the molten core as well as to the atmosphere.

This is so elementary an inference that it would have been advanced long ago had it been known that the earth contains more electrons than protons. But the well known constant escape of electrons in low latitudes was regarded merely as the result of the entrance of solar electrons around the magnetic poles and their subsequent emission in low latitudes. To the writer this seemed a begging of the whole question, for it tacitly assumed an escape of more electrons than protons from the sun. If more electrons were escaping from the sun why not from the earth also? Now, the only way in which an excess of electrons could escape constantly from either sun or earth would be as a result of conversion of more protons into radiant energy. We know that the heat of the sun and of other stars is probably the result of the conversion of matter into radiant energy. So we are taking only another step when we add that in this conversion, more protons than electrons suffer "the heat death."

Picture both electrons and protons as composed of systems of photons spinning about many radial axes, the direction of spin being opposite in an electron to that in a proton, thus accounting for their opposite nature. Let such a system be submitted to enormous gravitative pressure, and it seems likely that it must collapse. We know that certain atoms are broken up by impacts. Carry the same pressure process a step farther and the constituents of atoms, their protons and electrons, must disintegrate into their constituent elements, which probably are those nuclei of radiant energy called photons.

Since the proton is about 1,800 times as massive as the electron, it is much less mobile. Hence the electron must tend to move faster from a region of intense heat under the action of radiant pressure. Rising more quickly, electrons sooner escape the critical pressure that destroys them. Thus more protons than electrons suffer "heat death" in every great mass. Consequently every great mass is negatively charged and is constantly emitting electrons. This is the writer's conception of the cause of the earth's negative surface charge and its emission of electrons. The spectroscope shows the sun's surface charge to be negative also.

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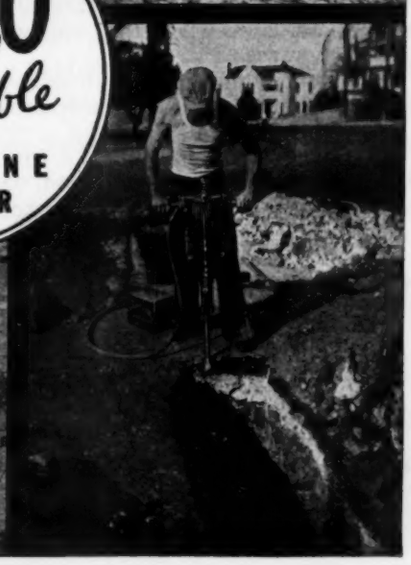


earth. The recent discovery that the sun's corona is a sphere indicates that it is an electron-shell. Probably the sun's incandescent photosphere is another one. Since all such shells must rotate, and since their magnetic interaction must cause periodic variations in the streams of emitted electrons, it follows that the earth must vary periodically as to its magnetic fields and as to the number of solar electrons that bombard it. This must cause cyclic variations in the number and intensity of air whirls. Each air-whirl due to electrons has a magnetic core of oxygen which greatly intensifies the whirl by drawing more electrons into it. Hence the vertical circulation of the air is periodically increased, thus increasing rainfall and lowering temperatures near the earth's surface.

Add to this a movement of the magnetic poles in great circles or ellipses, reaching an extreme diameter of about 30 degrees, and you have all that is needed to cause latitudinal inversions of climate. Moreover, at the very times that ice-ages occur great crustal uplifts will occur, because molten-cyclones are caused by the same electronic forces that cause atmospheric cyclones. In addition, at such times the earth's molten core must become more oblate, causing changes in sea level, for more electrons then travel spirally toward its magnetic poles; and as they attract one another magnetically they cause compression of the earth's core along the magnetic axis. Other effects of this compression and evidence of its existence are given in a recent paper by the writer in the Pan-American Geologist, reprints of which will be sent on request. The same article discusses the cause and frequency of ice ages, and of much longer climatic cycles.

▼

Report on Highway Accidents

Results of a study of traffic conditions and measures for this improvement, carried out under a special $75,000 federal appropriation, are embodied in a report submitted to Congress on Feb. 12. The investigation was carried out under the direction of the U. S. Bureau of Public Roads, with the cooperation of a number of organizations and institutions that had previously worked in the particular field investigated. The report, based on extensive field studies, is published in six parts as House Document No. 462, Parts 1 to 6, and covers the following subjects:

Part 1 presents a picture of the basic differences in traffic laws in the various states. Drivers passing from state to state are subject to varying road rules, control devices and laws, which they are apt to violate through sheer ignorance.

Part 2 shows the dire need of analyzing accident causes in order to prevent future accidents, and the importance of studying physical aspects of a case before evidence is destroyed. The difficulties of investigating accidents immediately, particularly in rural areas, are outlined, together with a description of methods used by trained accident investigators.

Part 3 is closely related to Part 2. It pictures the variations and inadequacies of motor-vehicle accident reporting throughout the United States.

Part 4, Official Inspection of Vehicles, deals with another phase of accident prevention. It is based on experience in the 15 states having state-wide motor-vehicle periodic-inspection laws for all motor vehicles.

Part 5 presents case histories of fatal highway accidents. It analyzes the case histories of 1,715 fatal highway accidents from the 1936 official records of representative states and cities.

Part 6 discusses the accident-prone driver. The records on drivers kept by the department of motor vehicles of Connecticut were selected for study because of the carefully-kept card file which made it possible to check on accident-repeaters. The 6-year record of every tenth name in this card file—a total of 29,531 drivers—was studied and compared.

These 6 reports may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The price of Part 1 is 15 cts. Parts 2, 3, 4 and 5 are 10 cts. each. The price of Part 6, in course of publication will be 10 cts.

▼

Palmer New President of A. G. C.

The following officials have been elected by the Associated General Contractors of America, which held its 19th annual convention in Washington, D. C., Feb. 8 to 10.

E. P. Palmer, Secretary-Treasurer of Senior & Palmer of New York, was elected president of the association for the coming year, succeeding W. A. Klinger, of Sioux City, Iowa, who held office in 1936 and 1937. Guy F. Atkinson, president of Guy F. Atkinson Co., of San Francisco, was elected vice-president at large.

New members of the association's Board of Directors elected for the coming year are:

C. Wohlgemuth, Jr., Washington, D. C.; Carroll Griffin, Atlanta; Matthew Cummings, Boston; William J. Goble, White Plains, New York; L. S. Oakes, Minneapolis; J. H. Pittman, Houston, Texas; W. W. Clyde, Springville, Utah; and Theodore Shoemaker, Portland, Oregon.

Members of the association's Advisory Board for 1938 are:

Fred Birch, Great Falls, Mont.; John N. Mullen, Minneapolis; F. B. Schwaderer, Cass City, Mich.; R. E. Richie, Charleston, W. Va.; D. W. Challis, Sewickley, Pa.; Ralph E. Mills, Frankfort, Ky.; Franklyn Weisgerber, Hackensack, N. J.; Richard Hopkins, Albany, N. Y.; Herman F. Cole, Ames, Iowa; J. Grover Estes, Memphis; H. A. Dick, Portland, Ore.; Franklin Nelch, Springfield, Ill.; Thomas B. Carmichael, Akron, Ohio; Frank B. Bowers, Salt Lake City; Grady Miller, Atlanta; Ford J. Twaits, Los Angeles; Thomas F. Coleman, Providence; William Muirhead, Durham, N. C.; Oscar B. Coblentz, Baltimore; C. V. Burghart, Chicago; H. S. Tullock, Leavenworth, Kans.; and A. J. McKenzie, San Antonio.

The secretary-treasurer of the association is E. Marshall Rust, of the Rust Engineering Company, Pittsburgh and Washington.

Division chairmen and vice-chairmen for the coming year are: Heavy Construction and Railroad Contractors Division; J. S. Miller, vice president of the Dravo Corporation, Pittsburgh, chairman; Oscar Coblenz, president of the McLean Construction Co. of Baltimore, vice-chairman; Building Division: Russell H. Hunter, vice president of Starrett Brothers & Eken, New York City, chairman; Thomas B. Carmichael, C. W. & P. Construction Co., Akron, Ohio, vice-chairman; Highway Division: M. W. Watson, Topeka, Kans., chairman; F. W. Parrott, C. F. Lytle Construction Co., Sioux City, Ia., vice-chairman.

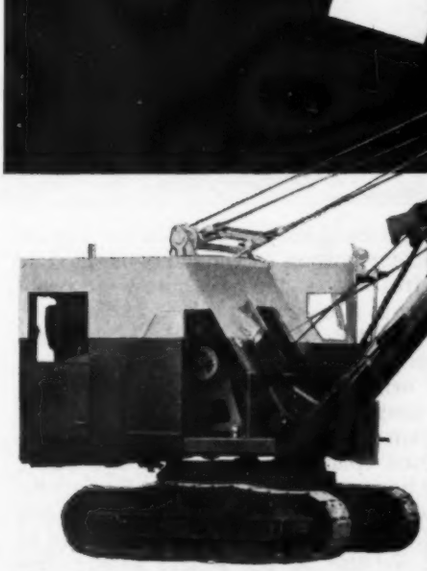
▼

AMERICAN INSTITUTE OF STEEL CONSTRUCTION MEETS IN OCTOBER—The next convention of the American Institute of Steel Construction, Inc., will be held Oct. 10-14 at French Lick Springs, Ind. V. G. Iden, 200 Madison Ave., New York, N. Y., is secretary of the Institute.

95 B 1938

Built TO GIVE YEARS OF SERVICE!

● NOT MERELY MONTHS • •



"The Marion we bought two years ago on its first job handled over 500,000 cu. yards of hard, mountainous digging without the slightest difficulty or delay," says Capt. W. W. Boxley, W. W. Boxley Sons & Company, Roanoke, Va.

Utilizing the same engineering principles and built to the same exacting standards as Marion's larger machines, Marion clutch-type excavators are able to defy the years and roll up imposing service records in any field of operation. Long life, ease of handling, and low operating and maintenance costs make these excavators the outstanding values in today's market. Write for additional reasons why they enjoy such big sales. ● There is a Marion for every material handling job. » » » »

The MARION

STEAM SHOVEL CO., MARION, OHIO - U.S.A.

An Example of High-Grade Landscaping on Route 201, Town of Pomfret, Conn. The ferns and native shrubs were conserved when roadside grass was mowed.

THE MAINTENANCE OF SHOULDERS AND RIGHTS-OF-WAY

A Review of Problems and Methods in Various States

The Second of Three Installments

By JOHN C. BLACK
Field Editor, Roads and Streets

LAST month we told something of maintenance operations in Michigan, Wisconsin, Illinois and Missouri—a neat and interesting Mid-West group. This time we go East, West and Center—Connecticut, Washington, Nebraska. Interesting observations can be made on both the likenesses and dissimilarities of methods in different states; but these we shall leave to the reader, contenting ourselves for the present with the single thought that improvement marches on.

Connecticut

The Connecticut State Highway Department divides its maintenance supervision and operations between a Bureau of Maintenance and a Bureau of Roadside Development, the latter having charge of all areas beyond the gutter line.

Bituminous Shoulder Treatment

In practically all cases shoulders are bituminously surface-treated to the gutter with various grades of tar or asphalt, depending on the material of which the shoulder is composed. They are maintained in practically the same manner that is used on bituminously treated travel paths. As this system has been in operation for a number of years the greater portion of shoulders on all state highways are thus treated, and the grass and weed problem has been reduced to a minimum.

Shoulders are re-treated whenever occasion demands in the same manner that the travel path is treated. In general, after the original treatment has been applied and the shoulders consolidated, one additional treatment a year will keep them in reasonably good condition. In a few cases a second treatment may be needed where traffic is extremely heavy or roadway extremely narrow.

Costs.—Costs vary greatly, depending on the location and length of haul, but in general a re-treatment can be made for between 2c and 3c per square yard. This covers the cost and application of the bitumen, covering with sand, and the necessary dragging.

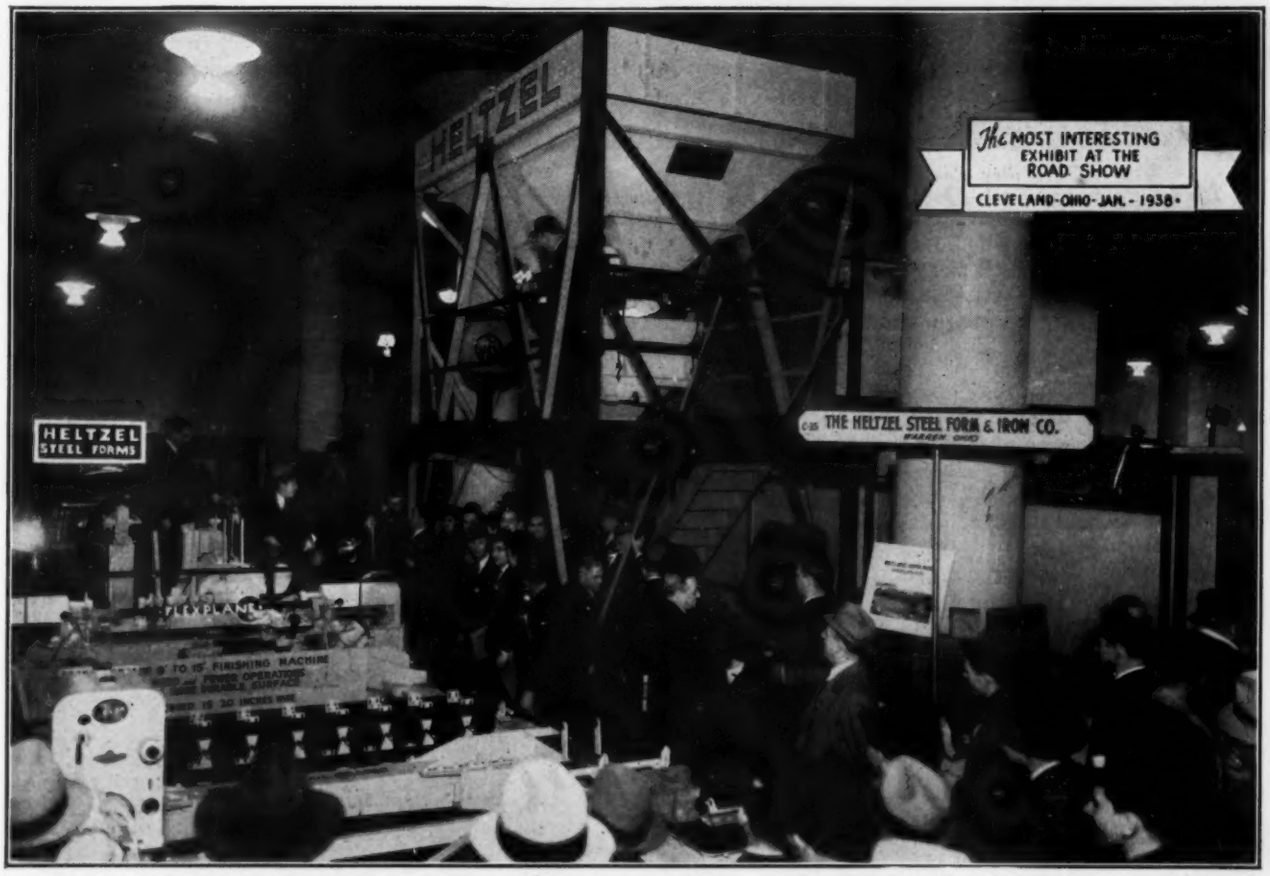
Organization and Activities of the Bureau of Roadside Development

Connecticut follows the principles stated by the Joint Committee of the American Association of State Highway Officials and the Highway Research Board: "Roadside development must conserve, enhance and effectively display the natural beauty of the landscape through which

FLEXIBLE ROAD JOINT MACHINE CO.

MARK THIS . . .

Only One "FLEX-PLANE" Finishing Machine required to build roads 9 to 15 feet inclusive — forward and backward screeding — screed 20″ wide. Money cannot buy a better machine.



Heltzel BUILDS IT BETTER

BINS, PORTABLE
BINS, STATIONARY
CEMENT BINS, PORTABLE
CEMENT BINS STATIONARY
CENTRAL MIXING PLANTS
BATCHERS (batch trucks), AUTOMATIC DIAL OR BEAM SCALES
BATCHERS (truck mixer), AUTOMATIC DIAL OR BEAM SCALES
BITUMINOUS PAVING FORMS
ROAD FORMS (with lip curb and integral curb attachments)
CURB FORMS
SIDEWALK FORMS
SEWER AND TUNNEL FORMS (made to specifications)
SUBGRADE TESTERS (Scratch Template)
SUBGRADE PLANERS
TOOL BOXES
FINISHING TOOLS FOR CONCRETE ROADS (edgers, straight edges, etc.)

HELTZEL STEEL FORM & IRON CO. WARREN, OHIO, U.S.A.

On Wilton Road, Town of Litchfield, Conn.
The picture shows a newly-graded slope after seeding and rolling. The rounding of the upper edge improves appearance and reduces sloughing.

the highway passes as well as provide maximum safety, utility, economy, and recreation facilities by means of proper location, design, construction and maintenance of the highway." . . .

"To conserve the landscape is to so adjust and adapt the highway as to make maximum practical use of the landscape without unnecessarily disturbing the balance of nature. This is accomplished by preservation of desriable native growth, outstanding topographical features such as water courses and geological formations, scenic formations, scenic values and historical sites."

Organization.—The Bureau is in charge of a Director and an Assistant Director. It comprises five main branches designated as:

1. Roadside Development District A
2. Roadside Development District B
3. Roadside Development District C
4. Roadside Engineering Section
5. Roadside Supply Section

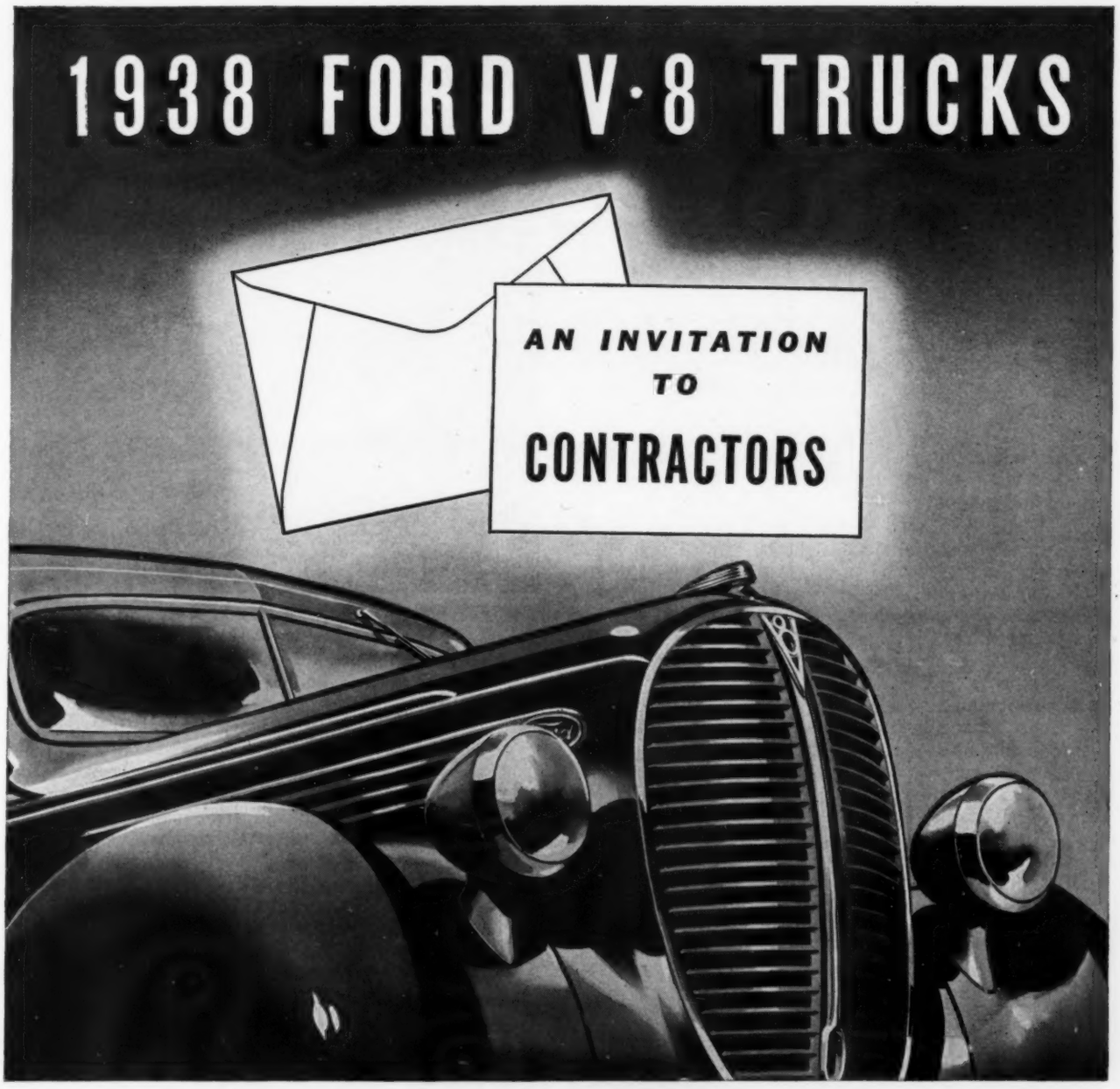
The Roadside Development Districts are branches of the administrative organization, based upon a division of the State into three territorial districts. Skilled and unskilled laborers are organized in landscape groups in each district, each group under a qualified landscape foreman, who is assigned a specified territory within the district. The landscape groups, as occasion demands, are organized in gangs, each gang under a qualified assistant foreman. Each district is in charge of a district overseer. The Roadside Engineering Section is in charge of an Engineer of Roadside Development with Assistant Engineers to meet the demands of the work. The Roadside Supply Section is in charge of a Landscape Administrative Assistant.

Functions.—The activities of the Bureau are manifold, and the scope of its work exceedingly broad. Its major functions are:

1. To examine construction plans submitted by the Engineer of Location and Design and to prepare plans for roadside development on each project.
2. To inspect all proposed construction or reconstruction work before contracts are let so as to conserve good native trees and shrubs that would be destroyed by the construction work; and to arrange for the stripping and piling of top soil when it can be economically saved for future landscape work.
3. To establish and maintain State Highway Department nurseries, only, for the development of salvaged or collected native plant material; for the storage of surplus purchased material; and the growing of such stock not obtainable from local commercial nurseries.
4. To grade, seed or plant raw slopes following the construction of highways through cuts and fills, so as to stabilize the embankments and thereby not only add beauty to the roadside but eliminate erosion and the cost of maintenance.
5. To plant trees, shrubs and vines in order to provide shade and roadside beauty by the filling in where needed to harmonize with the natural landscape.
6. To construct highway parks or gardens upon waste areas of land, particularly at town, city or state entrances.
7. To construct and maintain parking areas, recreational and picnic grounds at suitable locations.
8. To maintain the older shade trees in a safe condiction.
9. To maintain roadsides by the cutting of weeds and grass and the selective trimming and pruning of shrubs and trees, so as to provide safety to the traveling public, and to open up landscape and water vistas.
10. To give particular attention to the safety of our traffic by the proper inspection and maintenance of roadside conditions such as rock cuts, earth slopes and embankments, the trimming of trees, and other growth to provide sight line at dangerous curves, approaches to railroad crossings, highway intersections and bridges.
11. To authorize the granting of permits for location of public utility poles and other structures, and for the necessary trimming and removal of trees to provide for public utility service and the development of abutting property, and for the open-

Smoothing and Distributing Operation on a Connecticut Highway Following a Fresh Application of Tar and Sand. The finisher is the ordinary 3-blade drag, or hone. Treatment is the same for shoulders and main bituminous surface.

1938 FORD V-8 TRUCKS



MAKE AN "ON-THE-JOB" TEST WITH YOUR OWN LOADS AND YOUR OWN DRIVER

The showroom is the place to see a truck. But only your own job can prove what it will do for you. There, under your own operating conditions, is the best possible place to discover what you can expect in performance and economy.

Your nearest Ford dealer invites you to try a 1938 Ford V-8 Truck or Commercial Car with your own loads and your own driver. For practically every hauling and delivery need there is a unit that gives the high Ford standard of dependability and economy. In addition to the new 134-inch and 157-inch wheelbase trucks and the new 112-inch commercial cars, there is an entirely new line of 122-inch one-ton trucks. The new Ford V-8 Trucks have improved braking, easier steering, stronger construction. The new One-Tonners and the Commercial Cars offer a choice of the famous Ford V-8 85 or 60 horsepower engines.

Arrange for an "on-the-job" test today.

FORD'S SEVENTH YEAR OF V-8 SUCCESS

ing of entrances to adjacent property, and the improvement of roadsides by the property owners.

12. To construct and maintain platform scales for the use of the State Police Department in checking on overloaded trucks.
13. To maintain and perpetuate historical sites and objects.
14. To prevent destructive insect infestations by approved methods of control.

Safety Provisions.—Items enumerated by the Bureau as tending to increase the safety of highway travel are:

1. Removal of dangerous trees.
2. Pruning trees to remove dangerous and defective limbs.
3. Maintenance of standard clearings and sight line on curves, railroad crossing approaches, bridge heads and intersections of highways by the removal of trees and shrub growth.
4. Maintaining clear vision of all warning and directions signs by the frequent cutting of weeds and other growth.
5. Removal from roadsides of all dead and inflammable material that might be ignited and cause forest fires.
6. Proper control under permit system of the location of all highway furniture such as public utility poles, electric light standards, water hydrants, signs, mail-boxes, boulders, and historic memorials.
7. Maintaining rock cuts to avoid rock slides.
8. Stabilizing gravel and dirt slopes and embankments by seeding or planting to stop erosion, and to prevent depositing of the material upon shoulders and traveled path of the road.
9. Constructing and maintaining highway sidings or parking areas to eliminate the dangerous parking of cars on pavement of roads.
10. Building of picnic grounds with parking areas to eliminate parking on road surface.
11. Proper grading of roadside to eliminate hazardous conditions and avoid the use of guide rail fences.
12. Construction of small park areas at intersections which may be used as rotaries to split traffic.
13. Developing of waste areas between newly straightened roads and curved sections of old highways into highway parks, maintaining the old section of highways for a short distance for parking purposes.
14. Removal of high embankments and stone walls at corners of intersecting highways to open sight line.

Bituminous Treated Shoulder Adjoining a Concrete Pavement in Connecticut.

Fate-Root-Heath Co.'s Silver King Mowing a Down-Slope to a Concrete Curb.

Native Stock Largely Used.—Five nurseries are maintained, in which native trees, shrubs and perennial plants salvaged from construction operations and obtained from other sources are cared for and developed for future use on the highways. The Bureau also uses various waste areas of highway land for temporary storage of plant material.

The care and maintenance of these stockyards fall to the foreman located in the adjacent districts, care having been taken to place foremen in charge who have a working knowledge of proper nursery procedure. The Assistant Director of Roadside Development has general supervision over all the nurseries.

It is the duty of each foreman to maintain his stockyard in an economical and expert manner. He must collect suitable plants to keep his nursery rows filled, cultivate when necessary, fertilize properly to insure satisfactory growth, and lift and transplant the stock to its permanent location in the proper manner to insure its living.

Through experience it has been found that the native salvaged stock responds exceptionally well to cultivation and to intensive fertilization. It has been the practice to leave collected plants in the nursery row for a period of two growing seasons, giving them careful cultivation and liberal fertilization. The result has been plants of graceful and stocky appearance with well formed root systems adapted to withstand the shock of transplanting to the roadsides. By this method, the loss from trans-

Modern Engineering Design *plus* the Safety of CONCRETE

Result in low accident rate on Chicago's Outer Drive

Read These Remarkable Figures!

•

One of the world's finest examples of building safety into a roadway is this section of the Outer Drive in Chicago. In four years more than 80,000,000 vehicles used this roadway, yet only two fatalities occurred; one a pedestrian and the other a driver who apparently went to sleep.

If all the roads in this country had the safety record of the Outer Drive, 30,000 lives would be saved each year!

One reason for this encouraging record is modern engineering design. Provision of 4 lanes in each direction, with a dividing parkway and with grade separations at all intersections, makes for an orderly flow of traffic.

The other reason is the pavement surface itself. This pavement is the type that the motoring public recognizes to be the safest, most uniform and reliable of all pavements —*concrete*. Concrete provides a sure grip for tires, rain or shine—a permanently true and even surface—life-saving visibility at night. So clear-cut are concrete's advantages that it outranks other materials six to one as the choice for new divided arteries such as Chicago's Outer Drive.

On 2-lane roads everywhere, as well as on multiple-lane arteries, the safety of concrete can help reduce the accident rate.

Paul G. Hoffman, president of the Studebaker Corporation and of The Automotive Safety Foundation, recently said:

"The record of Chicago's Outer Drive gives substance to the claims that the Limited Way program projected for Chicago would make 98% of the accidents which now occur on the ordinary type of roadway, a physical impossibility.

"If by some legerdemain a modernization of our important highways could be accomplished over night, thousands of lives would be saved and hundreds of thousands of accidents avoided."

PORTLAND CEMENT ASSOCIATION
Dept. A3-28, 33 W. Grand Ave., Chicago, Ill.

A National Organization to Improve and Extend the Uses of Concrete

SAVE LIVES WITH CONCRETE

A Connecticut Gravel Road on Which the Entire Width, Including Shoulders, Has Been Oiled and Dragged to a Uniform Cross-Section and Surface.

planting has been so small that it could be entirely ignored.

Plants collected from the woods and fields and immediately planted along the roadsides, where proper care is impossible, have proved far from satisfactory. Often the loss from such planting has run as high as fifty per cent.

Nursery-grown and foreign stock are also used to some extent.

In mowing operations along the roadsides, practical men are put in charge of the laborers to see that good, native, small trees, shrubs, vines, ferns and wildflowers are conserved, if in locations that do not interfere with sight line or drainage.

Washington

The maintenance of shoulders in the State of Washington is varied. The separation of the State into two parts by the Cascade mountains provides many types of climatic and soil conditions, each of which causes a separate problem of shoulder maintenance.

In Western Washington, rainfall is comparatively heavy and the growth of weeds, brush and grass is more or less prolific. In Eastern Washington the areas range from very arid areas to heavily irrigated sections. The situation in the mountain passes may also be considered as a separate condition.

Three Methods of Shoulder Maintenance

Shoulders generally are maintained by one of three methods—blading, mowing and adding gravel or bituminous material. Blading is accomplished by the use of a pull type of grader drawn by a four-wheel drive truck or by a motor powered grader. Mowing is done by power driven mower units or by mowers mounted on trucks. Shoulder material for leveling ruts is either taken from selected roadways material pits or surfacing material stockpiles of crushed stone or bituminous material.

Aeroil Power Weed Burner.
Burning Weeds Along a Right-of-Way.
The bugs are destroyed, too.

Dry Areas—Earth shoulders in areas where very little moisture is prevalent are maintained by blading only in early spring and late fall as any disturbance during the dry season loosens the material causing it to blow away or become easily rutted. Weeds are removed by hand cutting at such times as they become large enough to be a distraction or menace. The large weeds of the tumble weed variety are piled and burned when they are dry. Burning is done by hand or by means of a fuel oil burning retort. The burning cost, using the retort, is about $5.00 per mile.

Humid Areas—In Western Washington and in the irrigated sections, earth shoulders are maintained either by blading or mowing, depending on whether or not the growth of grass or weeds can be controlled. If the growth is such that a neat appearance and a smooth shoulder can be maintained, the mowing method is used. The annual cost of mowing varies from $25.00 to $50.00 per mile. The cost of blading varies with the number of trips required. On grass shoulders where ruts occur contiguous to the roadway pavement, they are filled, premixed bituminous material being used if available. If bituminous material is not available, selected roadway material or crushed stone surfacing is used.

Grass Seeding

The growth of grass is being encouraged in those areas where moisture is sufficient. A mixture which has proved satisfactory consists of the following varieties: Imported English Rye Grass, 37 per cent; Kentucky Blue Grass, 27 per cent; White Clover, 9 per cent; Chewing Fescue, 18 per cent, and Rhode Island Bent, 9 per cent. The seed is spread at the rate of 20 lb. per mile on shoulders of 5-foot width. The growth of grass reduces the growth of weeds and provides a very pleasing roadside appearance which is easily mowed and maintained. Grass close to the edge of the pavement prevents the formation of ruts, which are hazardous, and also provides a distinct color line marking the pavement edge. Grass will grow in areas where sufficient rainfall is received but not in the dry areas. Weeds will grow in the irrigated sections, but grass does not do well because the roadway is usually constructed with a grade line high enough to keep the shoulders dry.

Chemical Control of Weeds

Experiments in the control of weeds by chemical solutions have been attempted in several districts, and some have proved successful. In one instance the solution was made with one pound of sodium chlorate to one gallon of water. The mixture was applied on weeds and grass around guard rails by use of a pressure pump and spray hose and nozzle. The solution is effective, but care must be taken as it is inflammable when dry, and workmen must not let it get on hands or clothes. It will not harm stock.

In the Yakima District, an experiment was made with a product of a commercial spray company. Two mixtures were used, one for killing morning glory and the other for killing all vegetation. The first solution kills weeds by entry through the plant cells, while the other sterilizes the soil. The second chemical should be applied in early spring. Both were successful and it was found more economical to use the spray than to cut weeds by hand. Both of the above solutions are mixed with water, the amount depending on the degree of control desired. The solution is applied by a pressure pump

CUT YOUR ROAD REPAIR COSTS *with these* LITTLEFORD *units*

THE NO. 101 UTILITY SPRAYER

Do your patching, shoulder dressing, skin treatment and minor construction jobs better, and at less cost with a Littleford No. 101 Utility Sprayer. You can save up to $3.00 out of every $10.00 on material costs by using bulk material. The No. 101 heats faster and more safely than a kettle. The tank holds enough to last a patching gang all day. The motor-driven pump applies material through the spray bar or the hand spray at proper pressure for better penetration. Ask for data on No. 101 Sprayer.

NO. 84HD KETTLE

Your patching crew will get off to a quick start with plenty of hot stuff ready in a hurry when they use a Littleford No. 84-HD Kettle. They will get more patches in per day. Equip this heater with a Littleford hand spray attachment and you have the most satisfactory maintenance kettle money can buy.

The No. 84-HD is built to stand up under hard service. Trail it, loaded, full speed behind your truck. It will not splash over. It uses less fuel because Littleford "Double Heat Circulation" gives you double use of the heat from the burners.

Tell us how much work you have and we will show you the size you need. Ask for the facts on the savings a No. 84-HD will provide. Write, today, for prices and sizes.

BLACK TOP ROAD MAINTENANCE EQUIPMENT — LB — SINCE - 1900

LITTLEFORD

LITTLEFORD BROS.
454 EAST PEARL STREET
CINCINNATI, OHIO

of the variety used in spraying orchards. The use of these chemical solutions has been confined to weeds and grass in and around guard rails. Care should be used that livestock does not graze where the application is made, as the base of the product is arsenical.

Gravel Shoulders

Gravel shoulders are maintained by blading and the addition of new material as the old is displaced by vehicles. This type of maintenance is usually accomplished by a pull grader followed by a steel wire broom to sweep material off the pavement after it has been brought in by the grader.

Bituminous Surfaced Shoulders

A type of shoulder treatment that eliminates both blading and mowing as well as shoulder hazards has been used on Snoqualmie Pass and as far east as Cle Elum on Primary State Highway No. 2, U. S. No. 10. The shoulders were given a plant-mixed bituminous surface for their full width, which varies from 2 to 5 ft. The plant-mixed material was placed to a thickness of 2 to 3 ins. and the shoulders were bladed to a true cross-section. A tack coat of SC-2 oil was then applied. Crushed stone was mixed with SC-2 oil at the rate of 15 gals. to each cubic yard, and then spread on the shoulders. Compaction was secured with a 5-ton roller and then later with large size loaded trucks. The average cost of the operation was $710 per mile but due to the varying width and depth, no estimate of the cost per square yard could be made. The unit costs of the operation were as follows: crushed stone in stockpiles, $1.18 per cubic yard; oil and cost of mixing, $1.73 per cubic yard; hauling, placing and rolling, $0.95 per cubic yard.

Nebraska

In Nebraska an effort is made to obtain a growth of vegetation on all shoulders. Considerable seeding of shoulders on hard surfaced highways is undertaken each year. However, due to recent years of drought, little progress has been made in developing sodded shoulders in this manner. Where seeding or sodding is not undertaken successfully, native vegetation is permitted to grow.

Seeding and Sodding

Seeding is done both in early spring and early fall and in some cases the entire right of way out to the top of the back slopes is seeded. Brome grass generally is planted at the rate of 20 pounds per acre with a nurse crop of oats. Good results have been obtained in a number of cases. The Maintenance Department considers that Brome grass provides an excellent sod and has ample root growth to materially assist in preventing erosion.

During the summer of 1937, approximately 100,000 pounds of Brome grass seed was harvested from selected areas on the right of way where good stands prevailed. The seed is used the following fall or spring for new or reseeding.

Mowing and Special Treatments

In some cases, shoulders are treated with asphalt or gravel, but the general policy is to maintain them as sodded or grassed shoulders. In view of this policy, very little dragging or blading of shoulders is necessary. Both shoulders and roadside are mowed regularly during the growing season. The amount of mowing required depends upon climatic and soil conditions. With favorable soil and weather conditions, three to four mowings per season are required while under less favorable conditions, and in the more or less arid sections of the State one or two mowings are ample. Mowing

International Harvester Co.
A Rubber-Tired Horse-Drawn Mower at Work.

around structures, signs, and places not accessible with teams is done by hand.

While a few pieces of motorized mowing equipment are used, 90 per cent of the mowing is accomplished with teams and mowers. This method is used primarily for the purpose of providing farmers with much needed work on the highways, being necessary due to recent years of drought and failure of crops generally over the State.

One man with team and mower will take care of from 50 to 75 miles per season, depending upon the density and amount of the growth. The average cost per road-mile per year for the entire state to keep the shoulders and roadside mowed is approximately $15.00, this including cost of necessary hand mowing. One unit will mow from 2 to 5 miles per day, depending upon the area covered. In some sections where the growth is rapid, the shoulders are mowed more often than the roadside. Due to the fire hazard involved, very little burning of vegetation is undertaken.

Bindweed Treatment

In some sections of Nebraska there is a noxious weed known as "bindweed" (Convolvulus armensis), commonly referred to as "creeping Jenny," which is highly detrimental to farm crops. It is the policy of the Department to eradicate bindweed existing upon State highway right of way at all places where the land owner adjacent thereto undertakes eradication on his land. The treatment consists of applying 3 pounds of Sodium Chlorate in dry crystalline form, per square rod of an affected area. The chemical is applied any time after mid-summer and before the ground freezes in the fall. The cost of applying is about $11.00 per hundred pounds of chemical used. During the past year, the Department only spent approximately $3,000 for this purpose; however, greater expenditures will be made in the future due to increased activity among land owners.

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BITUMINOUS ROAD MATERIALS*

A Survey of Developments for 1937

By GEORGE W. ECKERT
Missouri State Highway Department
141 *Mumford Hall, University of Missouri, Columbia, Mo.*

PART I—Patent Literature

THE patents issued during 1937 indicate the trends and variety of methods which are involved in the improvement of bituminous materials. It appears that every type of physical and chemical agent available is being resorted to in order to improve bituminous substances for the purpose in hand. The bituminous patents in this review are arbitrarily divided into methods of: (a) preparation of asphalts, (b) the use of solvents, (c) addition agents, (d) coating of aggregate, and (e) emulsions.

Preparation of Asphalts

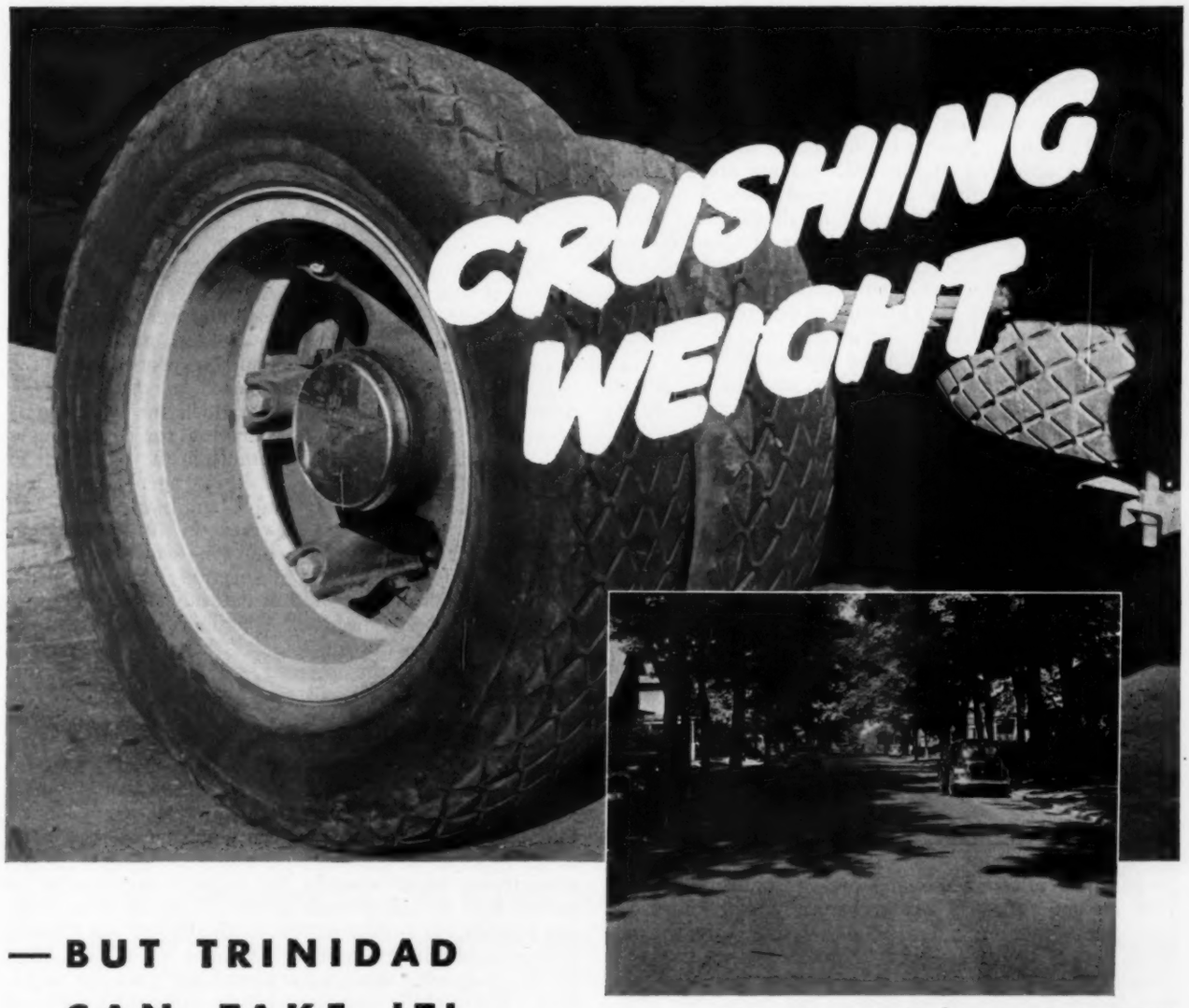
A continuous process for producing blown asphalts[32] from a petroleum base material has been developed in which the petroleum base passes through successive stages of blowing. The reaction zone consists of several pools through which air is passed, the petroleum material passing from one pool to another. In the oxidation of cracked hydrocarbon residues at elevated temperatures,[17] excessive oxidation can be retarded by the use of anti-oxidants. A method of preparing bituminous materials by blowing, consists of passing air through bituminous material at a temperature of around 266° F., to which .2 to 3.0 per cent of H_2SO_4 has been added.[27] The surfuric acid is of such strength that sulpho-acids are formed with the bitumen. A process of producing asphalt comprises the steps of blending asphaltic bituminous material with an easy flowing low viscosity index hydrocarbon oil, treating the resulting blended mixture with an oxidizing gas under conditions to oxidize the asphaltic material, and blending the blown mixture with a highly viscous low viscosity index hydrocarbon oil.[6] The production of asphalts having a reduced temperature susceptibility is claimed[57] by blending a bitumen, which contains over 20 per cent asphaltenes, with a hydrocarbon oil of low viscosity index. The blended material may be blown to reduce the susceptibility, and the ductility of the blown material increased by blending it with a highly viscous hydrocarbon oil of low viscosity index. In a method of producing an asphalt, a fluxing oil is amalgamated with a high melting point bitumen in powdered form.[1] The powdered bitumen is prepared by mixing a substantially cracked straight run residue from a mixed base crude with a hydrocarbon which has a melting point above about 120°F. and blowing the mixture to a melting point of from about 240°F. and powdering the blown product. A cracked bituminous cement useful for various purposes[10] consists of approximately 70-80 per cent of 80 penetration at 77°F. and the major proportion boiling below 680°F. A process for making bituminous compositions[5] comprises distilling an asphaltite at 698-752°F. until 15-25 per cent of its weight is lost. Material for use in road construction can be prepared from products condensed from vapors produced in a standard by-product coke oven plant.[3]

Use of Solvents

Since distillation and heating of asphaltic materials generally results in products having undesirable properties, much of asphalt research and practice is being turned to the use of solvents for the improvement of these materials. One process uses benzol[4] to dissolve certain constituents from a residuum, which has been vacuum distilled and then treated with oxygen, thereby eliminating undesirable substances. Another process consists of extracting a residual petroleum stock[64] with two or more solvents, separating the solvent layer containing, primarily, napthenic constituents and subjecting it to steam-blowing with a gas containing free oxygen. Liquefied propane, ethane, butane, phenol, cresol, aniline, furfural, or mixtures thereof are specified in a method for separating petroleum residual oils into fractions and recombining various of these fractions to give so-called artificial asphalts.[59] An artificial asphalt can be also prepared by adding a residue from an oxidized asphaltic oil to an extract from the solvent extraction of non-paraffinic hydrocarbons.[67]

Solvents can be used to obtain petroleum plastics from pitches[12] by treating the solvent and dissolved portion of the pitch in successive stages with sulfuric acid and finally treating with clay and elimination of the solvent. The steps in a process to produce asphalt from a semi-paraffinic type petroleum, which is normally unsuited for the production of superior grades of asphalt, comprise distilling the oil to remove various fractions, treating the residuum with selective solvents, removing the solvent from the soluble portion, and reducing this portion to the desired melting point and penetration.[8] Sulfur dioxide may also be used as a selective solvent for separating fractions of crude or residuum oil from certain constituents which might be undesirable.[13] A process has been described[38] for the extraction of bitumen from bituminous lignite by saponification of the constituents and extraction with low boiling solvent such as acetone or a hydrocarbon. Asphalt powder may be prepared by mixing fused asphalt with a low boiling liquid hydrocarbon and introducing the mixture into a chamber under temperature conditions which cause the asphalt to congeal to small particles and the hydrocarbon to evaporate.[41] A complete and stable asphalt solution is claimed by dissolving asphalts of the class consisting of Gilsonite and Syrian asphalt in a solvent consisting of at least 90 per cent of a paraffin hydrocarbon boiling between 50°C. and 200°C. and less than 10 per cent of an organic compound having an —OH or a ketone group, such as diacetone-alcohol, butyleneglycol-β ethyl ether, butyl alcohol, butyl ester of glycolic acid, ethyl ester of lactic acid, ethyl-propyl-ketone, acetone, acetophenone, and cylclo-hexanone.[33]

*This is a continuation of the survey which appeared in the March, 1937, issue of ROADS AND STREETS under the title: "Recent Developments in Bituminous Road Materials."



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Addition Agents

The term *addition agent* is used here to indicate materials not classed as bitumens, and which are only used in limited quantities with respect to the treated bitumen. The addition agents may be divided as inorganic and organic. Among the inorganic addition agents which have appeared in the 1937 patents are Portland cement,[65] ground mica and ground slate,[28] ground gangue from Ag and Pb ores,[40] alkali silicates,[45] resinates, silicates, borates, and carbonates of alkali metals, alkaline earth metals, Mg, Zn and Al,[46] and colloidal siliceous compounds.[18] Organic addition agents which have been developed are chlorinated polyphenyl,[60] chlorinated polyvinyl chloride,[23] "unchlorinated" polyvinyl chloride,[25] rosins and gums[57] and glycerol.[40]

Asphalt compounded with rubber, such as vulcanized rubber,[27] latex[50] and waste rubber,[62] is finding applications in road construction, impregnating paper and textiles, joint making, covering floors and walls, and for making damp courses for buildings. In the preparation of such bitumen-rubber compositions, sulfur[34, 54] may be added for vulcanization with or without activators or accelerators. Alkalies and protective colloids,[53] oxidizing agents such as MnO_2,[34] waxes, resins, and fats,[34] and NaCl[53] are additions which can be used with bitumen-rubber mixtures to counteract or improve certain properties of the compositions. Partial oxidation of the rubber and bitumen mixture can be accomplished by blowing with air.[34, 50] One rubber-bitumen composition comprises adding rubber to a bitumen-aggregate system, the aggregate of which is either a basic mineral or rendered basic by treatment.[52]

The Coating of Aggregate

As the behavior of an aggregate-bitumen mixture in a road may depend to some extent on the method of preparation, different methods are constantly appearing. One method[2] consists of mechanically admixing solid ingredients of a bituminous binder in finely divided particles with fluid ingredients to make a paste-like consistency, and then coating the aggregate with this mixture before the binder ingredients can completely amalgamate to form a cement. Another method[19] comprises admixing an aggregate with an aqueous emulsion of a soft bitumen until the emulsion is broken, and after the emulsion has broken, admixing the coated aggregate with a hard bitumen in the presence of a volatile solvent. A pavement can be prepared with a plurality of courses containing aggregate and bituminous binder for the aggregate, the binders in different courses having substantially different penetrations, and having a substantially greater penetration than the binder for the surface course.[16]

Aggregate can be coated first with an agglutinating agent of high softening point and composed of a fine powder (filler) and an asphalt and (or) tar as adhesive, then with a dry slightly oily and bituminous material made by intimately mixing ground stone with a tar product.[44] Another preparation comprises mixing a mineral aggregate and cresote oil and then blending the mixture with cold asphalt tar, or pitch.[51] An aggregate coating preparation[20] consists of a mixture containing 50 per cent asphalt having a penetration of from 200-300 at 77°F., 30 per cent petroleum naphtha, 10 per cent kerosene, and 10 per cent tar naphtha. A method of preparing a bituminous concrete paving material consists of coating an aggregate with a bitumen, then adding a fine non-powdered mineral, and next applying a quick drying bituminous primer, and provides a dry material which cements together upon compaction with pressure.[7] Before coating a silicious aggregate, its surface can be treated with solutions of iron salts to improve the adhesion of the aggregate and bitumen.[24, 49] A proposed method of forming a bituminous composition includes mechanically admixing an aggregate, containing a water soluble alkaline earth salt, and a water external phase bituminous emulsion and a salt.[9] The salt reacts with the alkaline earth salt to form a water-insoluble compound.

Emulsions

The preparation of bituminous emulsions remains an important part of bituminous investigations. The question of the preparation of these emulsions can only be answered by knowing the intended use, materials used in conjunction with the emulsion, the properties of the bitumen itself and the agents used in preparing the emulsion, and the conditions to which the emulsion is to be subjected. In a recent process for producing a stable emulsion,[22] an initial emulsion is prepared to which more bitumen and emulsifying agent are added, thereby producing a more stable emulsion than if all the emulsifying agents were present in the initial emulsion. A bitumen-in-water emulsion sensitized to coagulate by adsorption and absorption when contacted with solids substantially void of natural salt precipitating agents comprises a bitumen, containing heat decomposition products of calcium soaps of the natural petroleum acids contained in the bitumen, emulsified with alkaline water containing an alkali soap of a fatty acid.[14, 15] A slow breaking emulsion can be prepared by passing a quick breaking emulsion containing a small amount of caustic alkali, through a centrifugal pump and simultaneously adding regulated quantities of an alkaline metal salt.[11] A process for preparing a stable emulsion of bitumen comprises dispersing an emulsion of the water-in-oil type in a concentrated aqueous solution of an emulsifying agent whereby the original emulsion is reverted into an oil-in-water type.[61, 43] Stable acid reacting bituminous emulsions are obtainable[63, 59] by treating a basic emulsion, produced by the aid of NaOH, Na_2SiO_3, or Na_3PO_4, with small quantities of citric acid or tannic acid. Hydrophilic emulsions can be prepared by mixing emulsions, of natural or artificial bitumen with high and low melting points, so that the lower melting bitumen is never liquid and has a congealing point at which it agglutinates the particles of the higher melting constituent.[42] A stable emulsion of coal tar and asphalt flux oil can be prepared in steps involving emulsifying the asphalt flux oil by means of oleic acid and ammonia and incorporating the coal tar and oleic acid with the flux oil emulsion.[21] Other methods of preparing bituminous emulsions include:

(a) Dispersion in an aqueous alkaline solution of an alkali soap or solid rosin containing an amount of calcium or similar rosinate and stabilized by adding a normally coagulative electrolyte solution.[36]

(b) Dispersion of a tar or bitumen containing sulfur, oils and a solvent with a solution of $CuSO_4$ or other metal sulfate.[48]

(c) Dispersion with an emulsifying agent of a soap of an acid, e.g., abietic acid and incorporating a resinous paste, obtained by fractional distillation of pine oleoresin, with the emulsion.[47]

(d) Emulsifying with a saponifiable material and a mixture of lime and an alkali carbonate.[35]

(e) Dispersion in a hot dilute solution of alkali with assistant emulsifying agents of a fatty acid pitch, e.g., stearin pitch, and a protein compound.[55]

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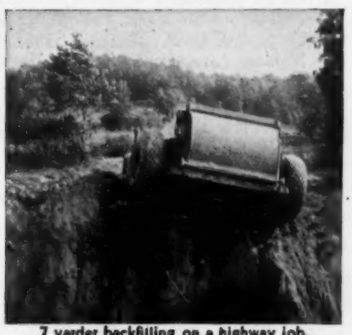

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(f) Incorporation of a salt of a metal of the second series of the second periodic group with an aqueous clay emulsion of bitumen, to provide that a dried film of the emulsion be water resistant.[29]

(g) Incorporation of a copper salt of a monobasic acid with an aqueous clay emulsion of bitumen to provide that a dried film of the emulsion be water resistant.[30]

(h) Incorporation of a lead salt with aqueous clay emulsion of bitumen to provide that a dried film of the emulsion be water resistant.[31]

Acknowledgment—The author wishes to thank Dr. Hans F. Winterkorn for his helpful suggestions and for his permission to release this material.

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(Part II—Periodical Literature on the Developments in 1937 in Bituminous Road Materials will appear in the April issue)

Moisture Content of Stabilized Bases and Subgrade

The following note from Highway Research Abstracts is based on work of the Iowa State Highway Commission as set forth in a Highway Research Census:

The object of this investigation was to determine the moisture content of stabilized bases and of the subgrades under these bases at different periods during the year. The density of the stabilized base was also determined, and the physical characteristics of both the base and subgrade.

The bituminous wearing course was removed, a sample taken of the stabilized base, and the density determined by filling the hole with oil. At first samples of the subgrade were taken to a depth of 5 ft. below the base, but there was such a difference between the moisture content of the stabilized base and the first foot of subgrade immediately below the base that later only this first foot of subgrade was sampled and the moisture content of each one inch determined.

The results of moisture determinations made in 1936 during the dry part of the year showed moisture contents in the base of about 2.4 per cent for the road having the lowest moisture content, to 6.4 per cent for that of the highest. These same roads had moisture contents of 2.7 and 7.3 per cent, respectively, in the spring of 1937, shortly after the frost was out of the ground. The moisture content of the first foot of subgrade immediately below the base was about 16.0 per cent.

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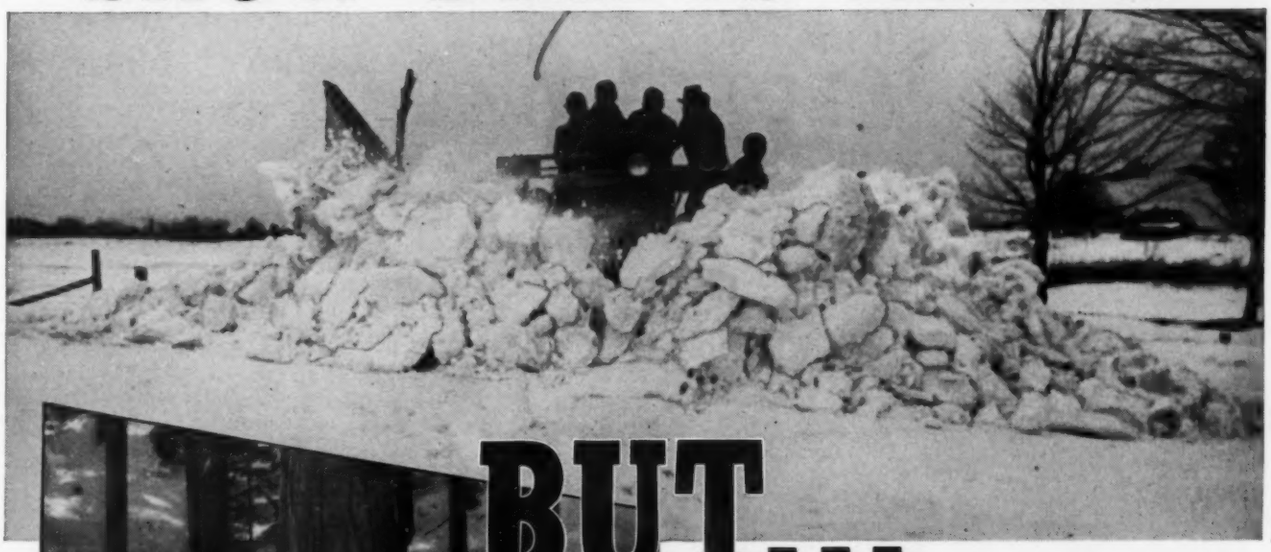

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EDITORIAL

Water Then Bitumen *vs.* Bitumen Then Water

IN STABILIZATION of soils with bituminous admixtures, I have observed that construction practice varies on one point, particularly.

At first glance the variance may not appear important. In fact, in talking with one engineer who has had considerable experience with stabilized roads using bituminous admixtures, I understood him to say that the variation in method had no particular significance. He said it made no difference which way the work was done.

I refer to the sequence of mixing the water and the bitumen with the soil aggregate mass. A state engineer told how, on one job, after he had thoroughly mixed the soil and aggregates he added water up to the optimum and disced it into the spread loose material. Then he spread the bituminous material and mixed it with a motor grader. Then the material was compacted.

Another state engineer told how, on one job, after he had thoroughly mixed the soil and aggregates, he next spread the bitumen over the loose material and worked it with a motor grader. He then added water, up to the optimum, mixed it with the bituminous mass and compacted.

These two methods differ radically in theory. In the first case the water is added first and can be taken up by the clay and colloids. The bituminous material is added second and can only coat the wetted clay and colloids to waterproof them. In the second case the bituminous material is added first to the dry soil-aggregate mixture thus waterproofing the dry particles. Water was then added, as demanded for the optimum moisture content from predetermined laboratory experiments, and the mass mixed and compacted.

Can both methods be equally correct, theoretically? If not then why do they produce apparently equally strong, hard, desirable road surfaces? Is the bituminous material incorporated to waterproof dry particles and destroy their colloidal properties, or is it incorporated to waterproof optimumly wetted particles to prevent change in volume by either evaporation or additional water absorption?

In the case where bituminous material is incorporated with the dry soil aggregate mixture first, it occurs to me that the addition of water would be detrimental. In practice this does not work out. Why?

Views of Others

Answers to letters to whom this editorial was sent replied as follows:

I believe that the engineer you quoted in the second paragraph is correct in his statement that it makes no difference which way the work is done.

The water which is present in a tar soil stabilization job has two functions. One is to dampen the soil so that it may be more readily mixed with the tar, and the second is to prepare the soil so that it will be compacted to its maximum density by the method employed on that particular job. This last moisture content is what is called the optimum moisture content.

The amount of water necessary to dampen the soil sufficiently for efficient mixing is probably somewhat less than the optimum moisture content; but apparently considerable more water can be present and the mixing operations will still be efficient.

As a matter of practical procedure, therefore, water sufficient to produce the optimum moisture content, or several per cent above the optimum moisture content, may be added to the soil prior to the application of tar. It is possible, however, to do efficient mixing with less than this moisture content, and if more convenient, the addition of sufficient water to bring the percentage up to the optimum moisture content may be delayed until after the tar has been applied.

As a matter of fact, the soil particles are certainly not entirely covered with tar during the mixing operations. No mixing apparatus yet devised is able to spread the tar out in as thin a film as would be necessary to coat the entire surface of the soil particles, keeping in mind that this surface may be as much as twelve acres for a cubic foot of soil. It is probably some time after the soil stabilization job has been finished before all of the soil particles are entirely coated with tar.

The function of the tar undoubtedly is to coat the soil particles and waterproof them. It is not necessarily true, however, that these soil particles are ever entirely dry when coated. The contrary is probably the case.

The stabilized soil mixture does not retain the optimum moisture content after consolidation. In fact, it would probably be detrimental to the road if it did. There is a gradual drying out and reduction in the moisture content down to 5 or 6 per cent.

In the soil stabilization process with tar, therefore, it is advisable to have the soil in a damp condition to facilitate the mixing with the tar, and it is necessary to have the optimum moisture content present in the soil at the time of consolidation for most efficient results.

As long as these two requirements are satisfied, it makes little difference when or how the water is applied, and the job may be organized so that the water can be applied at the most convenient time.

GEO. E. MARTIN
Consulting Engr,
Gen'l Tarvia Dept.
The Barrett Co.

NU-ARCH CULVERTS, made of Granite City Culvert Stock, embody the latest features of design, set a new high standard in strength and long life.

CULVERTS LAST LONGER

...when made of Granite City Culvert Stock!

Two things cause culverts to weaken and break down: Corrosion due to uneven distribution of spelter; and bending due to thin base metal.

Neither of these can happen if your culverts are made of Granite City Culvert Stock! Granite City Stock is laboratory controlled from start to finish... tested and checked to meet your specific needs... then certified in writing as to base metal analysis and spelter weight.

Wide experience has proved that Granite City Culvert Stock passes inspections consistently and easily. This is largely due to the fact that Granite City Steel Company specializes in culvert stock, and stakes its reputation on dependable quality.

Granite City Culvert Stock is made in three base metals: Copper Iron; Copper Steel; Pure Iron. You can always be sure of quick delivery from the thousand-ton stock carried at the mill. For positive satisfaction insist on Granite City Culvert Stock.

GRANITE CITY STEEL COMPANY

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As a theoretical consideration, I think that adding water to the soil before applying the bituminous binder should serve to facilitate both the distribution of the binder and the compaction of the treated soil. Possibly the addition of the water after the application of the bituminous binder would serve to facilitate principally the compaction of the soil.

C. A. HOGENTOGLER,
Senior Highway Engineer,
U. S. Bureau of Public Roads

As you probably know, our experience in stabilizing soils with bituminous materials consists of two somewhat different types of construction.

In one type sandy or silty soil is mixed with cut-back asphalt. Generally the final mix contains approximately 4 per cent asphalt. It has been discovered that the presence of a small amount of moisture aids materially in the mix but that too much water causes the cut-back asphalt to wash off of the grains of sand. This mixture is compacted by traffic over a period of several weeks and practically all of the moisture has to be evaporated from the mix before compaction can be secured.

In our work to date with tar in stabilizing clay soils we find that the presence of moisture is beneficial as an aid to easy mixing. We believe that it would be impossible to coat thoroughly the dry particles of soil with the small quantities of tar which we use. The tar-soil mixture is also compacted at the optimum moisture content and we find that wetting the soil to slightly above the optimum moisture content prior to application of tar is the most efficient method for mixing and that the moisture can usually be evaporated to the optimum with ease during mixing operation. In some instances it has been necessary to re-apply moisture to the mix after most of the moisture has been evaporated, but we found it difficult to incorporate additional moisture uniformly.

W. H. MILLS, JR.,
Testing Engineer,
South Carolina State Highway Dept.

It is first necessary to rather carefully understand the mechanics involved, or rather the electrical phenomenon which governs the dispersion of liquids through aggregates and the coating of such aggregates. Perhaps I should not say understand, because I don't believe anybody does truly understand the entire situation. We do know, however, that the character of the aggregate itself is of tremendous importance. For example, one kind of clay of a given particle size will take up a given bituminous material rapidly, whereas another of the same size but different chemical make-up will behave entirely different. In general the addition of moisture in finely divided aggregates is conducive to the better distribution of the bituminous material throughout the mass. Furthermore, with certain aggregates, when the asphaltic material is added in the presence of moisture, there is a greater or less degree of emulsification. This may be a straight emulsion or an inverted emulsion which in turn depends upon the make-up of the aggregate.

It is true that under certain conditions the bituminous material can be added first and the moisture second, and apparently good results obtained. In these instances it is probably that there is already a certain amount of contained moisture in the aggregate sufficient to produce the first dispersion of bituminous material, and that with the addition of more water, the diluting and dispersing of the bituminous material is still further carried on.

While emulsified asphalt was used almost alone in stabilization of dense graded mixtures such as clays at first, it has been found that in the presence of many aggregates, even the rapid curing cut-backs are partially or completely emulsified and readily dispersed throughout the mass.

In conclusion, I would emphasize the fact that laboratory experiment is of the greatest importance in this field. Furthermore it does not need to be the ordinary type of laboratory because the engineer with an ordinary mixing bowl and a spoon, plus a graduate for measuring water and liquid asphaltic material, can carry out some pretty good experiments of his own to determine the facility with which various mixtures may be made.

BERNARD E. GRAY,
Chief Highway Engineer,
The Asphalt Institute

Write Personally

ONE senator made a remark that twelve individually written letters meant more to him than a petition signed by one hundred of his constituents.

We present this to show the necessity of writing to our congressional senators and representatives instructing them to support federal aid as it has been proposed. Gatherings like the recent meeting in Minneapolis where the Northwest Good Roads Association was formed should be sponsored in various parts of the country, and after the organization is effected each member should, upon his return home, write a letter to his senator and his congressman.

Seven states, represented by 1,200 good roads advocates, united their strength in making a demand on the President of the United States and the members of Congress that federal aid for trunk highways, county secondary roads and grade crossing elimination be continued in full on its present basis. This would mean defeat for the program proposed in Congress last December that federal aid funds be curtailed and the highway users' tax money, which in the past has been in large part allocated to the states, for highways, be diverted to other federal government purposes.

The formation of the Northwest Good Roads Association was a spontaneous action taken on the motion of Rep. Carl Eastvold of Ortonville after the 1,200 dinner guests hailing from all sections of Minnesota and the delegates from neighboring states had heard discussion on the subject by Congressman Wilburn Cartwright, of Oklahoma, chairman of the house committee on roads, Congressman Dewey W. Johnson of Minneapolis, Commissioner Elsberg and other authorities.

The seven-state gathering forwarded to the White House and to the members of the roads committees of the United States senate and house a resolution condeming the proposal to cancel or curtail federal aid as a move which would disorganize the highway program of the nation and disrupt "one, national defense; two, universal transportation, including farm to market roads; three, the employment program; four, public safety programs; five, the tourist industry; six, the general economic welfare."

The resolution commended governmental economy but vigorously denounced diversion of direct federal levies on highway users to any other than highway purposes, and pointed out that the federal government has prohibited the states from doing the very thing that such a program would effect.

While this is a highly commendable action, it is not enough. Each one who attended the meeting should write an individual letter and also, urge his friends to do so. Write personally.

South Bend

BITUMINOUS MATERIAL DISTRIBUTOR

1908–THIRTY YEARS' EXPERIENCE–1938

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MUNICIPAL SUPPLY COMPANY
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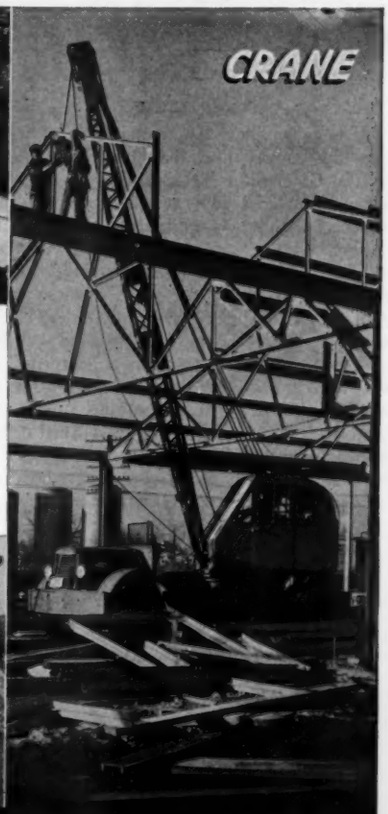


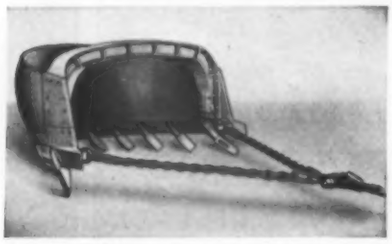
FROM EVERY ANGLE
- - A Practical Investment
3/8 yd. MICHIGAN 1/2 yd.
SHOVEL-CRANE
Write for Bulletins RS and RS2

MICHIGAN POWER SHOVEL Co
BENTON HARBOR, MICHIGAN, U.S.A.

NEW EQUIPMENT AND MATERIALS

New Scraper Bucket

A newly designed 3 cu. yd. Crescent scraper bucket of extraordinarily light weight has been announced by Sauerman Bros., Inc., 488 S. Clinton St., Chicago, Ill. The new bucket weighs only 2050 lb. as compared with the 3,300 lb. weight of the standard 3 cu. yd. Sauerman Crescent bucket. The saving in weight is attained without any sacrifice of structural strength and is accomplished partly by use of special



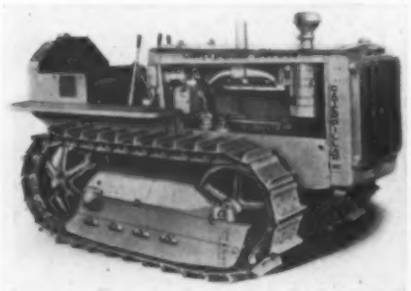
New Style 3 cu. yd. Sauerman Crescent Scraper Bucket

alloy steel and partly by changes in design which permit constructing the shell of the bucket of thinner plates than before. The new bucket is stated to dig and haul a load of dirt weighing about 4½ times as much as the bucket itself. The type of scraper bucket manufactured by Sauerman Bros., Inc., 25 years ago weighed almost as much as the load of dirt is handled, so the latest Crescent type of bucket represents considerable progress in the direction of conservation of power for useful work.

▼

New Tractor

A new, smaller, Caterpillar Diesel tractor—the Diesel D-2, has been announced by the Caterpillar Tractor Co., Peoria, Ill. Developing 25.5 Hp. at the drawbar, the Diesel D-2 has a 4-cylinder, 4-stroke cycle engine, with a bore and stroke of 3¾ in. by 5 in. To insure quick starting of this engine, even under the most adverse conditions, an independent, two-cylinder, horizontally opposed, 4-cycle gasoline engine is used. This engine, with a bore of 2¾ ins. and a 3-in. stroke, develops 10 Hp. at 3,000 r.p.m., offering ample power to turn the Diesel engine against full compression until a desirable starting temperature is reached. A hot water manifold, on the front side of the fuel filter housing,



New Caterpillar Diesel D-2 Tractor

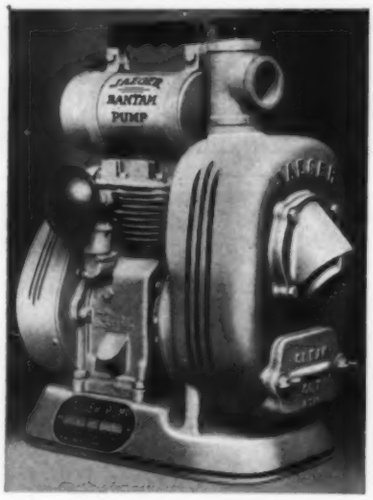
is another all-weather feature. This keeps the Diesel oil at the proper temperature, regardless of climatic or operating conditions.

A unique feature of the Diesel D-2 engine is the twin radiator, which has been developed by "Caterpillar" engineers—one is for cooling the water, and one for cooling the lubricating oil. Increased leverage on the steering levers insures for easy steering and with literally finger-tip steering control, the machine is flexible and easily maneuverable under all conditions. The proven design of heavy-duty, slow speed steering clutches is maintained. The master clutch lever is hand-operated, and the entire tractor is unusually accessible for maintenance and necessary adjustments.

▼

New Light Weight Pump

An automatic priming pump, built of aluminum alloy and weighing only 52 lb., is being offered by The Jaeger Machine Co., Columbus, O. Its rated capacity of 5,200 gal. per hour is said to be the largest ever developed by a pump of this light weight. The priming action, employing the Jaeger patented priming jet, insures fast self-priming at lists up to 25 ft. Including standard ¾-1 Hp. ball bearing



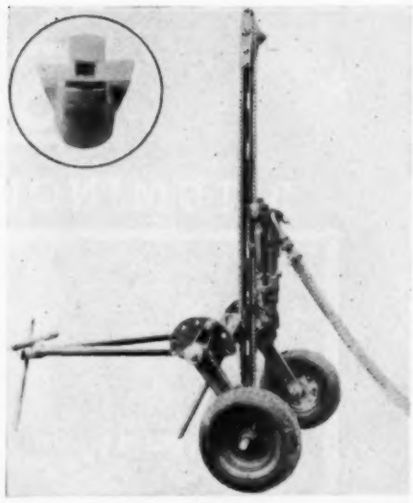
New Bantam Pump

engine with carburetor and gasoline tank of .4 gal. capacity, the Bantam measures only 9½ x 19 ins., may easily be carried by a boy or shoved into the front or back of any automobile. It is also furnished with ½ Hp. splash-proof electric motor which may be plugged into any light socket.

▼

New Drill Rig

A new drill rig, stated to be easily portable by one man, was formally announced at the Cleveland Road Show by the Sullivan Machinery Co., Claremont, N. H. This unit, known as the UW-161 Featherweight Drill Rig, weighs 375 lb. Its vertical height is 6 ft. 9 in.; overall length (less draw bar) 5 ft. 7 in.; wheel gauge 3 ft. 4 in.; overall width, 3 ft. 11 in.; steel change, 3 ft. This new drill rig uses the Sullivan L-12 hand-held drill for the drilling machine and the L-12 in turn is



Sullivan Class UW-161 Featherweight Drill Rig

run by the new Sullivan J-5 Automatic Chain Feed. With the use of this automatic feed, the operator can obtain the maximum drilling speed and efficiency from his machine day in and day out. Also, less time is spent in changing steels and in pulling steels. More time is spent in the actual drilling operation.

▼

New Snow Plow

A plow designed to lift the snow and roll it over the bank, permitting easier operation has been placed on the market by Johnson Snow Plow, Inc., Ainsley Drive, Syracuse, N. Y. There being no bulldozing effect when hitting a drift with this type moldboard, it is contstructed of lighter material, making it more flexible and easier to operate. The plow is carried on three detachable shoes, allowing it to oscillate and follow the contours of the road. The push frame is equipped with a special lift, which permits the operator to raise the heel of the plow, or put pressure on the cutting edge from the controls inside the cab of the truck. The lifting units for the plow and leveling wing, are electric motors, with reduction gears, which automatically locks itself in any position. These are controlled by self-releasing, reversing drum switches, mounted in the truck cab directly in front of the operator. It is claimed that it is not necessary to stop or back out of a drift to raise or adjust the wing, due to the high torque of these mo-

The Johnson Snow Plow

Above is a Sauerman Slackline Bucket dumping gravel into hopper on top of plant. Below is a Sauerman Drag Scraper making long side-hill cut.

SAUERMAN
LONG RANGE MACHINES

WHEN you have an excavation job that calls for moving dirt several hundred feet or more, it surely is economy to use a machine that will reach the entire distance and eliminate rehandling.

Sauerman long-range machines will do just that — reach any distance from 100 to 1,500 ft., and handle the digging, hauling and disposal of the dirt in one operation.

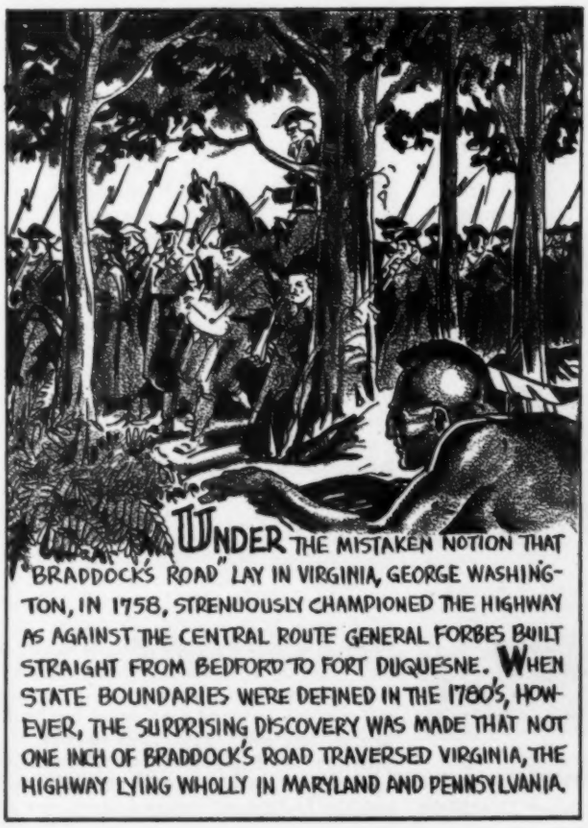
Use a Sauerman Slackline Cableway if your work calls for digging deep and dumping at a high point.

Use a Sauerman Drag Scraper wherever dirt is to be hauled over the ground, as in making cuts and fills, moving gravel from a bank, pit or stream to crusher, etc.

Write for Catalog

SAUERMAN BROS.
488 S. Clinton St.
CHICAGO, ILLINOIS

Did you know that—


UNDER THE MISTAKEN NOTION THAT "BRADDOCK'S ROAD" LAY IN VIRGINIA, GEORGE WASHINGTON, IN 1758, STRENUOUSLY CHAMPIONED THE HIGHWAY AS AGAINST THE CENTRAL ROUTE GENERAL FORBES BUILT STRAIGHT FROM BEDFORD TO FORT DUQUESNE. WHEN STATE BOUNDARIES WERE DEFINED IN THE 1780'S, HOWEVER, THE SURPRISING DISCOVERY WAS MADE THAT NOT ONE INCH OF BRADDOCK'S ROAD TRAVERSED VIRGINIA, THE HIGHWAY LYING WHOLLY IN MARYLAND AND PENNSYLVANIA.

Buckeye
Surface Material
SPREADER

GET ALL *the facts* ON THE **Buckeye** *before* YOU BUY ANY SPREADER *this year*

Ask the inspectors on jobs where Buckeye Spreaders are in use — they can tell you what we mean by Buckeye accuracy. Some will tell you that check weighing is unnecessary because they find Buckeye Spreaders give accurate measure of materials to specifications.

They approve, also, the better job that results from clean material, direct from the trucks. Roadside pre-delivery of material is almost entirely done away with — as is the resulting dirt, loss of time and material and extra expense.

For accuracy, speed and low cost of spreading, and simplicity of operation, — there is no machine that compares with Buckeye.

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tors, which are especially designed for this purpose. The electric power is generated by a special unit consisting of a four cylinder gasoline motor, directly connected to a 240 volt A. C. generator. The plow is made in various models to fit trucks ranging in capacity from 1½ to 12 tons.

▼

New Truck Mixer

A new truck mixer and agitator, stated to be entirely new in principle of operation, has been announced by the T. L. Smith Co., Milwaukee, Wis. The unique, duo-cone mixing drum is equipped with a combination charging chute and sealing door. There is no hatch to open or close.

The New Smith Mobile Truck Mixer

The drum rotates during the charging operation and mixing starts the instant the materials enter the drum. The company claims the new drum design insures a better mix. The batch is dry mixed and shrunk as it enters the drum. Big T-shaped spiral blades are said to produce a positive "end-to-end" movement of the aggregates. Water is pumped into the drum at 50 lb pressure, and is introduced through the feed opening. A special nozzle is used to secure a spray effect, thereby it is claimed, effecting a faster and more uniform distribution of water in the batch. The nozzle is located in the top section of the drum where it does not come in contact with the aggregates. Other features include: High discharge without hoist. Distributing spout carried on pivot bracket. Load carried in front of rear anxle. Accurately calibrated two-compartment water tank. Elimination of water bells in drum. Direct driven rotary turbine pump included as standard equipment. The unit will be available in 1½, 2, 3 and 4 cu. yd. truck-mixer sizes with corresponding 2, 3, 4½ and 6 cu. yd. agitator sizes. A new descriptive bulletin may he had on request.

▼

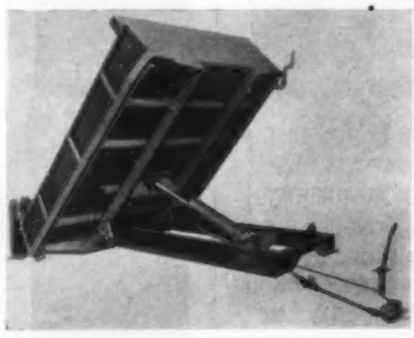
New Littleford Equipment

Three new pieces of equipment were displayed at the Cleveland Road Show by Littleford Bros., 454 East Pearl St., Cincinnati, O. A new motorized type of wheeled roller, a small 24-in. wide roller giving 150 lb. compaction per inch width of roller suitable for use in rolling patches, road repairs and small paving projects, attracted the most attention of the three new articles. A new bituminous road surfacing drag was displayed in a scale model and explained to all comers by its inventor and developer, a state highway man. This drag consists of several staggered rows of plows or mixing units which are free to follow the contour of the old road. It has 24 ft. long side runners which equalize the irregularities in the old road surface. The third new unit was small trailer type expansion joint filler, which appealed to those having long mileages of expansion joints to be filled. This unit attaches to and trails behind a heating kettle, connecting directly to the outlet on the kettle. Many miles of joints can be filled in this way in one day.

▼

New Hoists and Dump Bodies

W. H. Hammond, sales manager of the hoist and body division of Gar Wood Industries, Inc., Detroit, Mich., has announced the introduction of a complete, new and re-designed line of Gar Wood hoists and dump bodies for 1½- and 2-ton truck chassis—both short and long wheel-base — together with an improved line of heavy-duty dump-bodies, hydraulic hoists and mechanical hoists. The new Gar Wood units present many new improvements, and feature greater strength, reduced weight, lower mounting height, greater dumping angle and finer appearance in keeping with the trend of modern chassis design. Box-type tailgate construction and stronger, yet lighter body trunnion—tested to 55,000 pounds without yielding—distinguish the new C line of Gar Wood dump bodies. Models D6, D7 and D7L Gar Wood direct-lift hydraulic hoists, for example, have been completely re-designed. Practically every feature incorporates some improved advancement in design and construction. Steel forgings and lighter but stronger stampings are used extensively. Most costly materials have been built into the hoists, yet the price to the user remains the same.



One of the New 1938 *Re-Designed Gar Woods—the Model D6 Direct-Lift Hoist*

New Features of Etnyre Distributors

Three 1938 Etnyre "black-topper" distributors were exhibited at the recent Cleveland Road Show by E. D. Etnyre & Co., Oregon, Ill. Outstanding of the new Etnyre features, in these distributors, are the two "non-drip" spray bars. One of these new bars is known as the full-length circulating type, wherein the fluid circulates the complete length of a 24 ft. bar (or wider) either with the bar in horizontal operating position or with end-sections raised. End-sections of both Etnyre spray-bars can be "folded" up, for transit, eliminating necessity of removing same. This bar has the instant valve-shut-off at nozzle. Any width can be sprayed without necessity of "plugging nozzles" by simply disengaging valve at nozzle. The other new Etnyre bar is known as the "Siphon cut-off" type. Through a curved elbow the fluid flows to nozzles through the *top* of bar. Nozzles of both bars are spaced at 4 in. intervals. Bars can be quickly adjusted to any desired height to give a "Triple-Lap" Spray to insure uniform application. Another new patented feature is known as "Vacu-Flo," whereby the high vacuum available from the Etnyre pump is used to draw all fluid in either type of bar, leaving the bar clean, preventing "freezing" and dripping. The bars and header-lines slope to a low point where the vacuum line picks it up. Cold air does not "bubble through" the oil to "chill" it, but merely follows it to the low point. There is no obstruction in bar to prevent free flow and complete draining. 24 ft. bars are standard equipment, built in sections with leak-proof unions. Bars shifts 18 in., laterally, enabling operator to follow even edge. Weight has been reduced up to 1200 lb. by frameless mounting, standardized for all makes of trucks and trailers, and by the modern, streamlined, simplified design of Etnyre 1938 models. Protective steel skirting is used on both sides of distributor, covering fuel and air tanks on right side, incorporating a steel tool-box, with pilfer-proof lock and a covering for intake line on left side. This steel skirting also provides a trip-proof "walk" enabling operator to get to any part of distributor, quickly. Additional safety features are the

The 1938 *Model Etnyre Distributor*

Paint Metal with

EAGLE Sublimed BLUE LEAD

STOPS RUST CHEMICALLY

Lower cost per square foot

• A gallon of Sublimed Blue Lead will cover 600 to 800 sq. ft. of metal of average smoothness. Retards corrosion chemically. Does not crack, check or scale. Good for all coats. Meets Federal and A. S. T. M. specifications. Available in paste form. May also be secured from paint manufacturers by specifying Eagle Sublimed Blue Lead mixed to painting consistency.

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Check in at DeWITT OPERATED HOTELS

In CLEVELAND it's The HOLLENDEN

In COLUMBUS it's The NEIL HOUSE

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Unusually Comfortable, Modern Rooms; Good Food, Carefully Prepared and Served; Every Modern Hotel Facility and Reasonable and Uniform Rates

"Genuinely Friendly"

BAKER

For Your Tough Grading Jobs

BULLDOZERS

They insist on Baker Direct Lift Bulldozers and Gradebuilders wherever the going is tough and minutes count. Simply constructed, smooth operation, tremendous down pressure and freedom from costly delays make them first choice among careful buyers.

SCRAPERS

The improved Model 180 Baker Hydraulic Scraper (5-yard size) combines strength with light weight (built of copper-alloy high tensile steel). Dumps cleanly from the rear. Spreads evenly. Pan can be forced down under pressure. Investigate this outstanding scraper.

Send for Latest Bulletins on Any Baker Product.

THE BAKER MFG. CO.
506 Stanford Ave.
SPRINGFIELD, ILL.

1908 Serving the Highway Field for the Last 30 Years 1938

BAKER TRACTOR EQUIPMENT
BULLDOZERS
GRADEBUILDERS
ROAD ROOTERS
TRACTOR SCRAPERS
ROAD DISCS
MAINTAINERS
SNOW PLOWS

hinged pressure-relieving manhole cover and an inside cut-off valve that gives a double cut-off material between tank and pump. Another feature is the "Hi-Speed" heating system, utilizing Etnyre double burners which pass continuous heat through 12 flues in tank; 4 large main flues and eight smaller, return flues. Etnyre also offer one-man operation by the use of air-controls, located at cab of truck, enabling driver to operate and control spray-bars with ease. Other 1938 features are the new streamlined engine, mounted close to tank, saving space. Engine is equipped with 2-speed transmission. Either a Tachometer or Bitumeter with 5th wheel drive-assembly is offered as standard equipment. Etnyre's own design and manufacture of rotary pump is used.

▼

New One-Way Tractor Sweeper

A new one-way sweeper designed to meet the needs of municipalities, parks, cemeteries and large industrial plants is removing snow and dirt from sidewalks and drives, has been brought out by the Frank G. Hough Co., 919 North Michigan

Hough One-Way Sweeper

Ave., Chicago, Ill. The tractor on which the one-way sweeper is mounted is cranked through the front of the crankshaft, thereby leaving the rear power take-off on the tractor available for other work. The brush of this sweeper is set at 30 degrees to the right of the path being swept. A snow plow attachment blade 16 in. by 72 in. can be furnished. This is mounted ahead of the brush and is controlled by the same means as the brush lift. The plow is set to clear the ground by about 2 in. The plow thrusts aside the heavy snow and the brush sweeps aside the remaining 2 in. of snow.

▼

New Models FWD Trucks

Noteworthy changes and improvements in the 1938 line of FWD four-wheel-drive trucks were apparent from the new models shown at the recent ARBA Road Show in Cleveland. Designed to give maximum performance, and having new styling, the SU, SUA, and M series of models incorporate the principles adhered to by The Four Wheel Drive Auto Co. for 28 consecutive years of manufacturing. New features have been designed for increased comfort, convenience and style. For the three series, the entire cab, fenders, hood, and radiator have been re-designed to offer a more pleasing exterior and interior appearance. While the general principle of construction and units used are practically the same as in previous models, many refinements have been incorporated into these new models. On the SU and SUA models, the frame width has been changed to 34

New Model FWD Truck

in. from 36 in., which was previously the standard. The rear springs have been increased from 2½ in. wide to a 3 in. width, with new spring hangers, both front and rear. The swinging-shackle type of hanger is now being used to replace the sliding-shackle type of spring hanger. On the front of the truck, a channel steel bumper is now standard equipment. It is easily removable for installation of snow removal equipment. A streamline type of bullet headlight, adding materially to the appearance of the new models, is now a standard feature, also. Controls have been simplified throughout, and minor improvement altogether add to the ease of operation and effect a simplification of maintenance.

▼

New Feature of 1938 Kinney Distributor

Several new features have been included in the 1938 models of the distributors of the Kinney Manufacturing Co., 3529 Washington St., Boston, Mass. The weight of the tank has been substantially reduced by using alloy steel instead of ordinary tank steel. On the 1,000 gal. Model A tank the saving in weight is over 1,000 lb. The 1,000 gal. distributor exhibited at the Cleveland Road Show had an entirely new piping and control system with Westinghouse air-brake diaphragm controls used to actuate the spray valves. The air valve is mounted in the truck cab, placing the entire truck and distributor within the easy control of one operator. Duplicate control at the rear end is furnished at slight additional cost. Conversion to manual control can be accomplished in two minutes. The spray bars on the Model A distributor have a total length of 22 ft. in a combination of lengths which makes it possible to spray any width from 9 in. to 22 ft. Large pump capacity and control

The Kinney Distributor

arrangement are stated to allow instant starting of spray even at 22 ft. widths. Compressed air, automatically admitted as spray valves are closed, prevents excessive dripping by forcing remaining bitumen out quickly. The Kinney jacketed rotating pump is driven by a Ford V-8 60 HP unit with Ford transmission, giving two forward pump speeds and also a reverse, for pumping back to tank cars. Two types of spray nozzles are offered: the Kinney slotted type and the opposed jet type which produces a fan shaped spray at right angles to the jets. Either type can be furnished in various sizes as required. One hundred and forty nozzles and 6 blank plugs are furnished as standard equipment and extra nozzles can be supplied at extra cost.

▼

New Pumps

New aluminum pumps in the 2 in. and 3 in. sizes have been placed on the market by Marlow Pumps, Ridgewood, N. J. The 2 in. size weighs 98 lb.; the 3 in. 108 lb. Both pumps are equipped with a 4-cycle engine with tapered roller bearing crank shaft. Both are guaranteed to handle a suction lift of 25 ft. and a total head of about 50 ft.; capacity of 2 in. up to 120 GPM, of the 3 in. 180 GPM. Castings are of special aluminum alloy said to resist salt water and other corrosion.

New Marlow Pump

Pump is entirely automatic without any manual adjustments; the old-fashioned stuffing box has been replaced by the new type double end oil seal which is mounted outside the pump casing and therefore is not subject to abrasive action of grit in the water being pumped. Impellers are of bronze, of the open type and pumps are fitted with cast iron wearing plates on either side of the impeller; these plates can be readily replaced when worn.

▼

Luminous Highway Marking

A new type of luminous marking for traffic lines on highways and streets was exhibited at the A.R.B.A. Road Show at Cleveland by the Highway Safety Products Corporation, Empire State Bldg., New York City. The process involves the use of a liquid binder compound which appears like, and is applied the same as, any paint. For highway marking, it is applied with a brush or by any standard road marking machine, to which is attached a trailer.

Built to do a . . .
BETTER JOB!

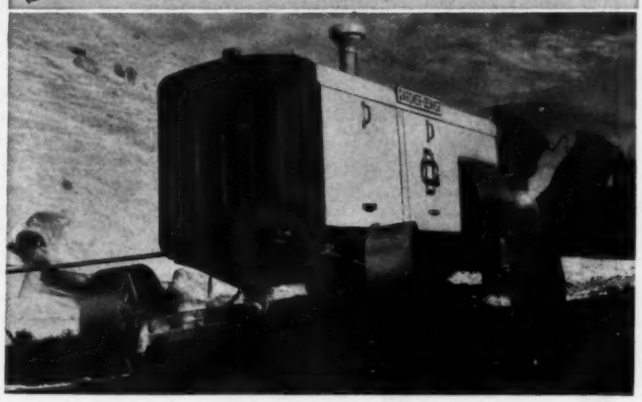
Sturdy construction combined with many modern and exclusive features of design account for Huber's lower operating costs—lower maintenance—plus the extra speed which enables it to do a better job in less time. Huber Road Rollers invite comparison. Buy by comparison—and you will buy a Huber. Write for Bulletins describing these modern machines in detail.

The HUBER MFG. CO.
Marion, Ohio

6 Sizes from 5 to 12 Tons Gasoline or Diesel.

Buy a **HUBER**

You're Buying for 1941
1940 TOMORROW
1939
When You Buy Gardner-Denver Equipment TODAY!



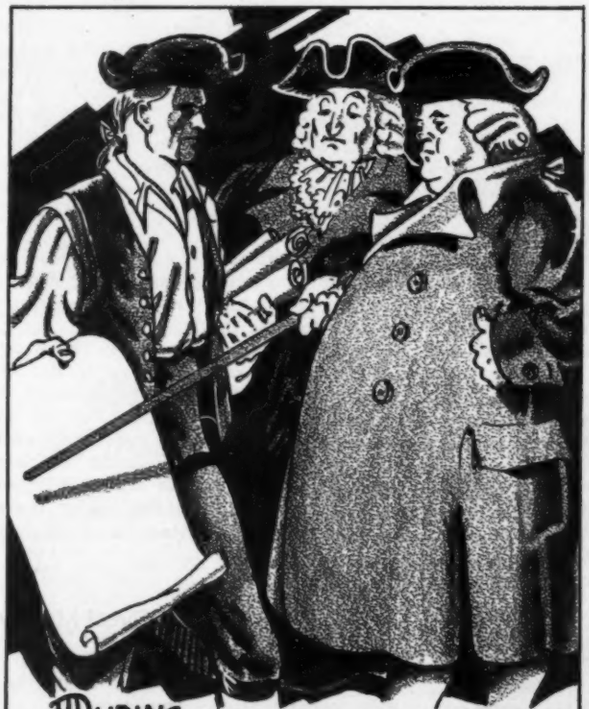
Gardner-Denver Portable Compressors are built for next year's job—and for those of the years after that. You get the long life of a stationary compressor in a Gardner-Denver Portable, because both Gardner-Denver portable and stationary compressors are *water-cooled for a full load.* They're dependable always, any season, anywhere.

Designed for long-time service in street opening and general demolition work wherever a powerful machine is desirable, Gardner-Denver B-72H Paving Breakers give you more power for every foot of air consumed. With Gardner-Denver B-72H Paving Breakers, too, you can plan for *tomorrow's* job. Write us for further information.

GARDNER-DENVER CO.
QUINCY, ILLINOIS
SINCE 1859

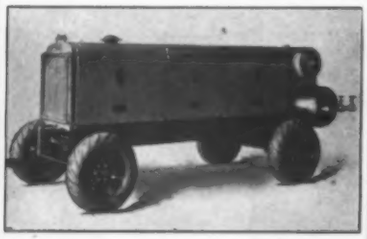
GARDNER-DENVER

Did you know that—



DURING THE COLONIAL ERA PARISH VESTRYMEN WERE THE AUTHORITIES RESPONSIBLE FOR THE MAINTENANCE OF ROADS IN SOUTH CAROLINA AND VIRGINIA.

OK AIR COMPRESSORS



● OK Compressors are made in a full range—in both single and two stages; gasoline, diesel and electric driven.
High Compressor efficiency, high drilling speed, dependability and low maintenance cost—have proven to extensive users in U. S. Government, States, Municipalities, Counties & Contractors, the outstanding superiority of OK Air Compressors.

O. K. CLUTCH & MACHINERY COMPANY
Columbia, Pennsylvania

(Advertisement)

Spray Controls—Air Operated from Cab; Lighter Weight, Feature New Kinney Distributor.

The Kinney Manufacturing Co., 3537 Washington St., Boston, Mass., made an instant hit at the Road Show with their new Bituminous Distributor.

For the Owner, faced with the desire of operating at a profit, the new air control of spray from cab (or platform); and the much lighter alloy steel tank—reducing dead weight by 1,000 pounds on a 1,000-gallon unit!—proved decidedly interesting.

To the Engineer, interested in accurate application, Kinney representatives emphasized the quick starting; full spray even at the end nozzles; large capacity Kinney pump; efficient heating unit; and tachometers.

Of direct interest to the Operator were the safety and easy handling features: fuel tank well away from the burners; ladders, and hand-rails; relief valves and vents; and the inside closing valve. Of general interest to all was the fact that Kinney Engineers had relied on proved equipment—Westinghouse Standard Air Brake diaphragms to control spray; and Ford 60 H.P. engine for which service is universally available. Complete details of this new Distributor are covered in new Bulletin A-1938—which the Kinney Mfg. Co. will gladly mail to interested parties.

This trailer device drops a coating of glass beads, approximately 0.015 in. in diameter, onto the freshly marked traffic line. The binder compound, which was especially developed for this purpose, and the glass spheres are both manufactured by the company in New York City. One of the greatest destroyers of white road paints is the ultra violet ray of the sun which causes cracking, flaking and discoloration. It is claimed for this Refractolite binder compound that the ultra violet rays have little or no effect upon it, because of its chemical components. Furthermore, when it has dried, the compound adheres very firmly to these glass spheres. This characteristic is highly necessary in order that the glass spheres will remain firmly imbedded. Another important quality is that the compound sets in less than 6 minutes, is absolutely free of all pick-up within 17 minutes, and the combination is completely dry and usable within 25 minutes under the most adverse conditions. The principle of the glass spheres is that of both refraction and reflection. These spheres absorb the rays of light playing upon them and return those rays of light back to their source practically parallel to the received ray. This applies to all rays from any source, and no one ray is affected by any other ray. An added feature is that any ray returned by such a sphere picks up the color of the binder compound into which these spheres are imbedded. The finished surface of the Refractolite Process is pebbly and is claimed to have visibility many times that required by the American Association of State Highway Officials' specification M35 relating to the requirements of zone paint to be used for roadway marking. The binder compound is furnished in white, yellow, black and red colors.

▼

New Lightweight Utility Trailer

The accompanying illustration shows the new light weight Utility trailer placed on the market recently by the C. R. Jahn Co., 165 W. Wacker Drive, Chicago, Ill. This new trailer which has been designed for the transportation of the lighter types of machinery, such as tractors, compressors, pumps, and small shovels and cranes, incorporates many new and interesting features. Dual-type wheels of heavily reinforced cast steel roll on oversized tapered roller bearings, and are all equipped with heavy duty full balloon pneumatic tires. Either four or six wheels are available. To expedite loading machinery onto the low flat deck of the trailer, the entire front axle assembly is removable. This is accomplished by a unique arrangement at the front end of the trailer frame, which serves as both a connection and turntable for the front axle. Loading is also made easier by means of a heavy jack screw built into the coupling assembly, which will raise or lower the trailer frame to accommodate practically all jobs with perfect safety. This new trailer, which will handle loads efficiently from 5 to 15 tons capacity, was described in our last issue but unfortunately the illustration shown with the description was of a heavier type of trailer.

New Jahn Lightweight Utility Trailer

▼

New Road Marker

A new, lightweight road marker that can easily be attached to a motor car or truck and operated by the driver, is now being manufactured by the Meili—Blumberg Corp., New Holstein, Wis. The marker is said to provide a clean, straight center line, free from feather edge. It operates over even or uneven surfaced roads. Two continuous bands form the outline for the spray. The paint is then automatically brushed, no surplus paint remaining around the marking. The machine is designed for marking black top roads as well as concrete roads, with any desired paint or hot asphalt. The stripe can be made narrower or wider by means of a simple adjustment. It takes about 15 minutes to mount the road marker on to the car or truck and the company claims about 65 to 75 miles of highway can be completed per day. After the marking unit is properly set alongside of the left rear wheel, the driver easily operates the equipment as the car proceeds. A guide is mounted on the front bumper. This guide enables the driver to accurately direct the movement of the vehicle. If desired, the guide may also be swung to the right to follow the gutter line or edge of pavement. No air compressor is required. Pressure is controlled by an especially designed pump connection with a by-pass valve, thus insuring complete agitation of paint at all time. A small single horse power gasoline engine operates the pump. The tank has a capacity of 60-gal. of paint.

M-B Road Marker

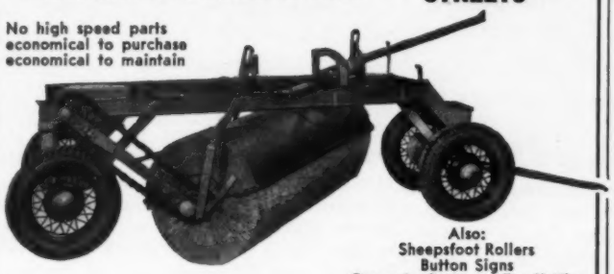
▼

Russell T. Gray, Inc., to Direct Murphy Diesel Advertising

Murphy Diesel Co., Ltd., Milwaukee engine manufacturer, announces the appointment of Russell T. Gray, Inc., Chicago, Ill., to direct its advertising. Business publications and direct mail directed to various industries are being employed.

GRACE SWEEPER FOR ROADS AND STREETS

No high speed parts
economical to purchase
economical to maintain



Also:
Sheepsfoot Rollers
Button Signs
Concrete Carts Tar Kettles

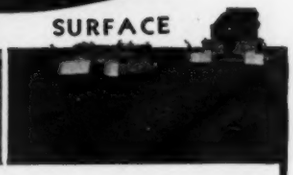
Made by

W. E. GRACE MFG. CO.

1822 CHESTNUT DALLAS, TEX.

JAEGER Adjustable SPREADER

BASE SURFACE



Smoothly Spreads Stone, Macadam and Bituminous—1" to 10" of Loose Material, 8 to 11 Ft. Widths.

Lays low cost roads, faster, smoother and with real savings.

JAEGER
BITUMINOUS PAVER

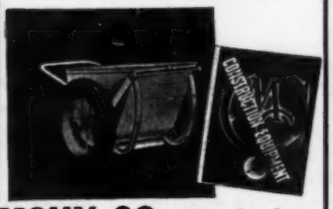
power-driven, adjustable 9 to 14 ft., does precision job without forms. Write for details.

THE JAEGER MACHINE CO.
223 Dublin Ave., Columbus, Ohio

Concrete
VIBRATORS and GRINDERS

Write for Circular on types, sizes and prices

ELKHART White Mfg. Co. INDIANA

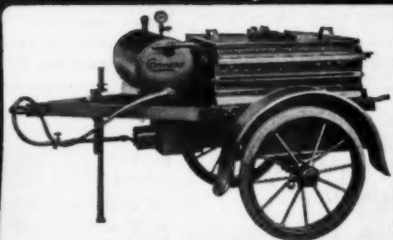


ALWAYS AHEAD!

With modern equipment for bridge and road builders. Get new catalog showing CMC Mixers—all types and sizes, Dual Prime Pumps, Hoists, Pneumatic Tired Carts, Wheelbarrows and Saw Rigs.

CONSTRUCTION MCHY. CO., Waterloo, Iowa

Connery's TAR & ASPHALT HEATING KETTLES



Style "J" 60-75 gallon oil burning kettle equipped with Timken Bearings, solid rubber-tired wheels and truck springs. A fine kettle for maintenance work and the price is low.

All sizes manufactured from 10 to 550 gallons.

Send today for our complete catalog.

3900 North Second St. Philadelphia, Pa.

CONNERY CONSTRUCTION COMPANY

NOW—The All Purpose Trailer!

AGAIN the C. R. Jahn Company offers the very latest in practical trailer design. The "ALL PURPOSE TRAILER" is especially designed for owners of ⅜, ½, ⅝ yd. shovels, weighing up to 35,000 lbs.

The "ALL PURPOSE TRAILER" will carry your compressor, pumps, small mixer, and other equipment. It is furnished with stake pockets so that side panels can be installed for carrying bulk materials if desired. The low loading platform has all the advantages found in the single purpose trailer. Look at the list of advanced engineering features offered in the Jahn "ALL PURPOSE TRAILER"—

• Single Purpose Trailer feature of removable front axle for convenient loading. • Loading platform as low as 24". • Strong wood platform fits flush with outer channel. • Standard size tires available at all tire dealers. • Brakes on rear wheels, loading ramps, lash rings, stake pockets, heavy draw bar safety chains, reflectors and flag sockets are all furnished as standard equipment. If you are in the market for a light trailer, be sure to check into these outstanding exclusive features offered in the Jahn "ALL PURPOSE TRAILER."

For more detailed information about the Jahn "ALL PURPOSE TRAILER," write or wire

"COME TO TRAILER HEADQUARTERS"

C. R. Jahn Co.
165 W. Wacker Dr., Chicago, Ill.

WITH MANUFACTURERS

Marion A. Smith

Marion A. Smith, Advertising Manager of Littleford Bros., Cincinnati, O., was killed Feb. 14 in a grade crossing accident. He was a regular fellow and his sudden death is a real loss to his many friends. His friendliness, his cheerful

Marion A. Smith

disposition endeared him to all he met. His body was laid to rest at Morrow, O., where he spent his childhood years and received his early education. He leaves a widow and two small children, Gerald 7 years and Mari Lou 7 months. He was born in April, 1907.

▼

Malcolm Now Manager Elastite Expansion Joint Dept.

Effective Feb. 16, 1938, V. V. Malcolm assumed his new duties as manager of the Elastite Expansion Joint Department, Specialty Products Division of The Philip Carey Co., Lockland, Cincinnati, O. Mr. Malcolm's duties will have to do with the sale and engineering of the company's elastite plate dowel, non-extruding, asphalt and rubber expansion joints and subgrade felt.

▼

Harry Terry Moves to New Offices

Harry Terry has moved to 8 So. Michigan Ave., Chicago. Until Feb. 1, 1938, he had offices at 360 N. Michigan Ave., Chicago. Mr. Terry, who was vice-president of The Cramer-Krasselt Co. for ten years, resigned Jan. 1, 1937, to open his own offices as advertising and sales economist. He works with both advertising agencies and advertisers in co-ordinating sales and advertising plans by making sales and market studies and advertising audits at the point-of-sale.

Leavenworth, Program Chairman for 1938 N. I. A. A. Conference

Ralph Leavenworth, Fuller & Smith & Ross, Inc., Cleveland, will head the program committee for the 1938 Conference of the National Industrial Advertisers Association. The time of the conference has been set for Sept. 21-23. The location chosen is the Statler Hotel in Cleveland. The conference is being sponsored by the Cleveland, Youngstown and Toledo chapters of N.I.A.A. "Plans for the conference are progressing rapidly," according to Stanley Knisely, Republic Steel Corp., and general conference chairman, whose committee on arrangements includes: Paul Teas, Paul Teas, Inc.; George Corey, Cleveland Twist Drill Co.; R. P. Dodds, Truscon Steel Co.; Richard Carr, Meldrum & Fewsmith Company of Toledo; E. B. Bossart, Bailey Meter Co., is chairman of the attendance committee; Louis J. Ott, Brass Co., George Corey, and K. W. Akers of Griswold Eshlemen Co., are in charge of hotel arrangements. Other committees now carrying forward plans for the conference are:

Publicity, E. L. Oldham, Cleveland Rock Drill Co.; Transportation, Harry H. Melville, Simmons-Boardman Publishing Co.; Panels, Robert E. Bandelow, The Caxton Co.; Entertainment, H. W. Fortey, Warner & Swasey Co.; Exhibits, J. L. Beltz, Thew Shovel Co., Lorain O.

▼

Schreiner Now Advertising Manager Carnegie-Illinois Steel

Carnegie-Illinois Steel Corporation, Pittsburgh, Pa., has announced the appointment of G. Reed Schreiner as advertising manager. Mr. Schreiner, who has been assistant advertising manager of Carnegie-Illinois since organization of the company Oct. 1, 1935, succeeds Charles R. Moffatt, recently appointed director of advertising of United States Steel Corporation of Delaware. Mr. Schreiner, was born in Pittsburgh, June 16, 1895 and received his A. B. degree at the University of Pittsburgh in 1916. Following World War service with the United States Army, he entered the advertising department of the former Carnegie Steel Co. in January, 1919, and has served continuously with that department of the United States Steel Corporation subsidiary.

▼

Talco Asphalt Appoints Sales Agencies

The Talco Asphalt and Refining Co., Mt. Pleasant, Tex., has appointed the following sales agencies for the handling of its asphalt products during 1938: American Bitumuls Co., Main office, Los Angeles, Calif.; sales office, Baton Rouge, Louisiana, A. W. Mohn, in charge; territory, Kansas, Missouri, Kentucky, Tennessee, Mississippi, Arkansas, Louisiana, Alabama and Georgia.

Amulco Asphalt Co., main office, Austin, Tex., B. F. Collins and J. O. Corwin, in charge; territory, Texas, Oklahoma and New Mexico.

Seneca Petroleum Co., main office, Chicago, Ill., O. E. Hulse, president; territory, Wisconsin, Illinois, Indiana, Michigan and Ohio.

Western Oil & Fuel Co., main office, Minneapolis, Minn., Henry M. Buskerville, President; territory, Minnesota, Iowa, North Dakota, South Dakota and Nebraska. These companies will handle a full line of asphaltic products manufactured by Talco Asphalt and Refining Co. at its Mt. Pleasant, Tex., refinery. The refinery is operated on Talco crude, transported by an 18-mile pipeline from Talco Asphalt and Refining Co.'s producing properties in the Talco Field to their plant.

▼

Innes to Represent Buda in Ontario

The Buda Co. of Harvey, Ill., has announced the appointment of J. S. Innes, Limited, corner of Bay and Yorkville Sts., Toronto, Ont., as exclusive representatives in the Province of Ontario for the sale of Buda-Lanova diesel and Buda gasoline engines for all types of industrial and automotive applications. J. S. Innes, Ltd., are also distributors for Cletrac tractors, built by the Cleveland Tractor Co. of Cleveland, O. All Model "AD" and "ED" Cletracs are powered with Model 4-DTC-196 Buda-Lanova diesel engines. The complete line of Buda-Lanova "Silver Crown" diesel engines, and Buda "Silver Crown" gasoline engines for marine use will also be handled by this Toronto representative.

▼

Devine Re-elected Chairman of Mixer Manufacturers Bureau

B. F. Devine, Chain Belt Company of Milwaukee, was re-elected chairman of the Mixer Manufacturers Bureau at the annual meeting in Cleveland during the American Road Builders Association Show. The Mixer Manufacturers Bureau is affiliated with the Associated General Contractors of America, Inc.

▼

Waco Plant Universal Atlas Wins Safety Trophy

The Waco, Texas, plant of the Universal Atlas Cement Co. has again won the Portland Cement association safety trophy for operating the entire year of 1937 without a disabling accident, it is announced by Gordon C. Huth, assistant manager of industrial relations for the company. Waco also won this trophy in 1936. C. A. Wallerstedt is superintendent of the plant.

New Holland
Jaw, Hammer & Roll Crushers • Revolving & Vibrating Screens • Conveyors, etc.
Write for Complete Catalogs Box 100
NEW HOLLAND MACHINE CO. • NEW HOLLAND, PA

ADVERTISING PAGES REMOVED

NEW CUMMER PORTABLE ASPHALT PLANT
Series 1200—For Hot or Cold Mix.
ONLY ONE DRYER USED. Either mixture quickly produced without change.
No Silos Required on Cold Mix. Process Continuous. Complete Plant set up in 3-4 days.
Cummer Heavy Duty Mixers—1, 1½ or 2 Ton Capacity.
THE F. D. CUMMER & SON CO., 900 B. F. Keith Bldg., CLEVELAND, OHIO

NEW LITERATURE

Trench Roller—A circular illustrating and describing its new trench roller has just been issued by the Galion Iron Works & Mfg. Co., Galion, O. This roller, stated to be an entirely new type, was especially designed for this purpose. It also can be used on repair, widening, relocation, elevating curves and on some types of new construction work. Adjustments are provided to level machine to suit any trench as frame has sufficient clearance to enable roller to work in depths of 18 ins. It will roll right up to edge of form or wall of trench and can be used to compact each course of material from the large stone for foundation to the top surface. Either 10 in. or 20 in. rolls can be supplied. Power is supplied by an efficient 4-cylinder gasoline engine.

Road Building and Maintenance Equipment—A useful condensed catalog of its equipment has been issued by J. D. Adams Co., Indianapolis, Ind. Eleven different road graders are illustrated and described. The catalog also contains descriptions and illustrations of the Adams elevating grades, retread paver and multi-blade maintainer.

Road Machinery—Its complete line for 1938 is illustrated and briefly described in a general pictorial catalog issued by the Austin-Western Road Machinery Co., Aurora, Ill. Included in this condensed catalog are descriptions and illustrations of crushing plants, distributors, dump cars, motor graders, road graders, elevating graders, low bed trailer, motor sweeper, plows, rippers, giant ripper, road drags, rollers, Roll-A-Planes, 12-yd. scrapers, 5-yd. scrapers, Fresno scrapers, other scrapers, shovels and cranes, snow plows, trail cars and washing plants.

Power Units—A circular has been issued by the Air Cooled Motors Corporation, 515 Madison Ave., New York, N. Y., illustrating and describing its line of Franklin air cooled industrial power units. An interesting feature of the circular is the description of the how and why of air cooling.

CLEARING HOUSE

ROAD MACHINERY FOR RENT

Practically New Demonstrator Models with Factory Guarantee—First 60 Days' Rent Can Be Applied Toward Purchase if Desired—REAL BARGAINS, ACT QUICK!

BITUMINOUS PAVERS:
2—9-12 Ft. Adjustable Pavers, late model with semi-crawler wheels. Heated screeds at small extra cost.

REBUILT FINISHING MACHINES:
1—9-11 Ft. Finisher
1—18-20 Ft. Finisher
1—20 Ft. Gas-Electric Finisher
1—20 Ft. Vibratory Finisher

MIX-IN-PLACE ROAD BUILDERS: Combination Traveling Pug Mill and Spreader Finisher, for One-Pass Mixing and Finishing of Bituminous Retread or Stabilized Base.

1—Model MP-1, Tractor Drawn Road Builder for light retread or stabilization, complete with screed and leveling attachment—85 H.P. engine on pug mill.
1—Model MP-2, Self-Propelled Road Builder for heavy mat or stabilization work. Twin pug mill, crawlers, screed and leveling device for mixing and finishing in one pass. 150 H.P. engine.

ALSO A FULL LINE OF MIXERS, PUMPS, HOISTS, TOWERS, SIDE DISCHARGE TRUCK MIXERS, SPECIAL ROAD GRADERS, CONCRETE SPREADERS, etc., for sale or rent. Write us for astonishingly low prices or rental terms.

THE JAEGER MACHINE CO.
223 W. Spring St. Columbus, Ohio

FOR SALE
3—10-Ton Huber Rollers.
1—10-Ton Austin Roller.
1—1,000-gallon Good Roads Distributor mounted on 5-Ton Diamond T Truck.
6—Pumps and other miscellaneous equipment.
LORENZ G. SCHUMM
La Porte, Indiana, Receiver for
A. W. Taylor Construction Company

TRANSITS AND LEVELS

New or Rebuilt
Sale or Rent
Complete and economical repairs to any make Transit or Level. We will take your old instruments in trade or buy them for cash. Write for RS-33 of NEW instruments and List RSL-33 for REBUILT equipment.
WARREN-KNIGHT CO.
Manufacturers of Sterling Transits and Levels
136 N. 12TH ST. PHILADELPHIA, PA.

Chicago Testing Lab., Inc.
and affiliated
Chicago Paving Laboratory, Inc.
Consulting and Inspecting Engineers
HUGH W. SKIDMORE GENE ABSON
Materials, Processes, Structures, Consultation, Inspection, Testing, Designs, Research, Investigations and Experts in Litigation.
536 Lake Shore Drive Chicago

FOR SALE
4—Aust. West. Autocrat 3-Wheel Rollers, 10-Ton, 6-Cyl., 3-Speed, master clutch, latest type.
1—Buff. Spring, 10-Ton, 3-Wheel Steam Roller.
1—Austin 10-Ton, 3-Wheel, Single-Cyl. Roller.
1—Universal Truck Crane.
3—Air Compressors, 110-220 and 210 C. Ft. Cap.
Box Number 130, Roads and Streets, 400 W. Madison St., Chicago, Ill.

WANTED
MUNICIPAL SALES AGENTS
To sell on liberal commission basis—Street Signs, Traffic Signs, Reflector Signs and Signals, Highway Beacon Lights, Parking Meters.
MUNICIPAL STREET SIGN CO.
233 Meeker Ave. Brooklyn, N. Y.

TRANSIT and LEVEL REPAIRING
Fully equipped modern shop—all makes repaired. Low cost—service unsurpassed—all work guaranteed.
Send for list of reconditioned instruments
We pay cash for used instruments.
NATIONAL BLUE PRINT CO.
518 W. Jackson Blvd. Est. 1914 Chicago, Ill.
Chicago Sales Representatives—W. & L. E. Gurley

FOR SALE
1—Baker Bulldozer for Monarch "50" Tractor.
1—Model "L" Allis-Chalmers Tractor.
1—Model "35" Allis-Chalmers Tractor.
2—7-Yd. Continental Scrapers.
1—Platform Trailer, 15 ton.
1—Rotary Scraper.
Used Parts for Monarch "50" Tractor.
H. B. FAITH EQUIPMENT CO.
2724 Auburn St. Rockford, Ill.
Phone Main 1540

Patents and Trade Marks!
Protect your most valuable assets. Expert service. Prompt attention.
LESTER L. SARGENT
Registered Patent Attorney
1115 K St. N. W. Washington, D. C.

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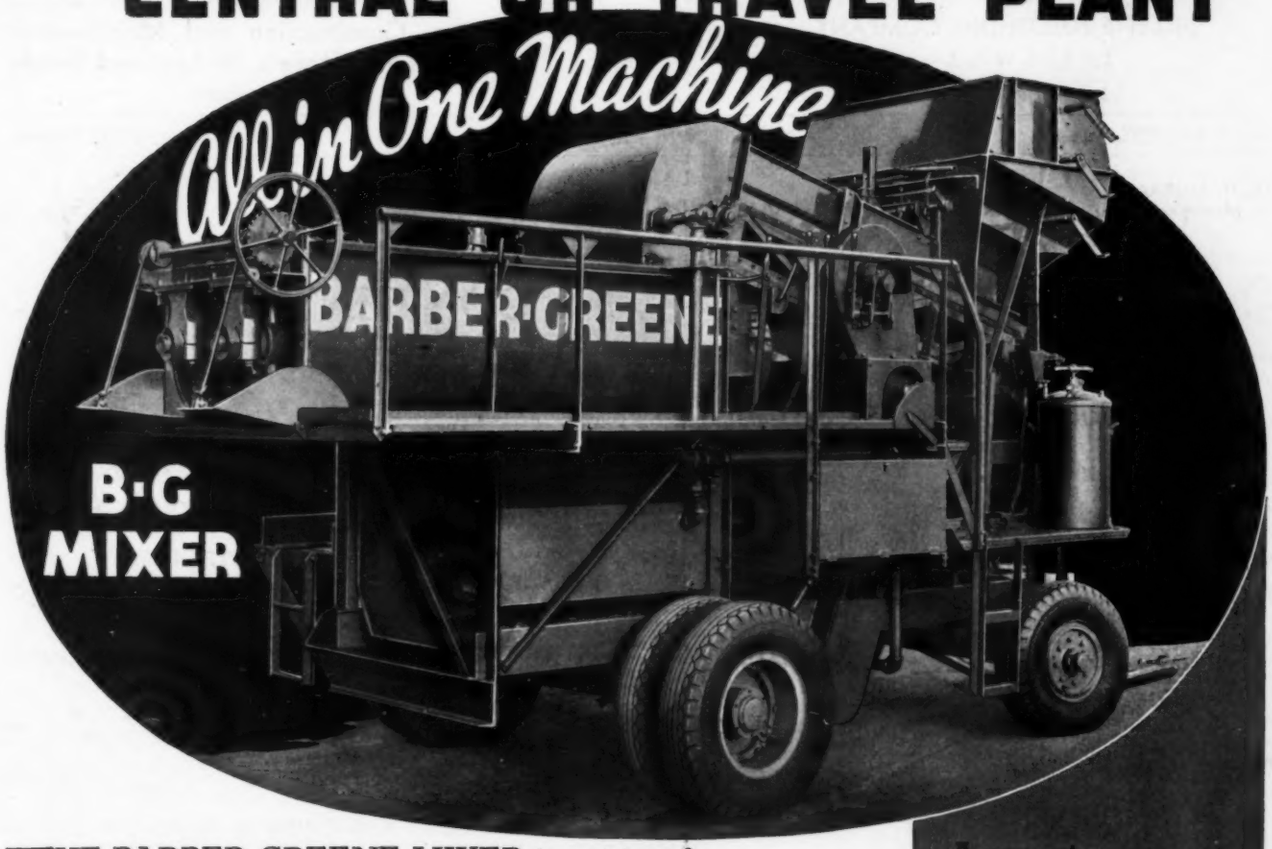

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Copyright 1938, by Gillette Publishing Company. Acceptance under the Act of June 5, 1934, authorized January 25, 1938, at Chicago, Illinois. Subscription price $3.00 per year in the United States, $4.00 per year for foreign mailing.

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